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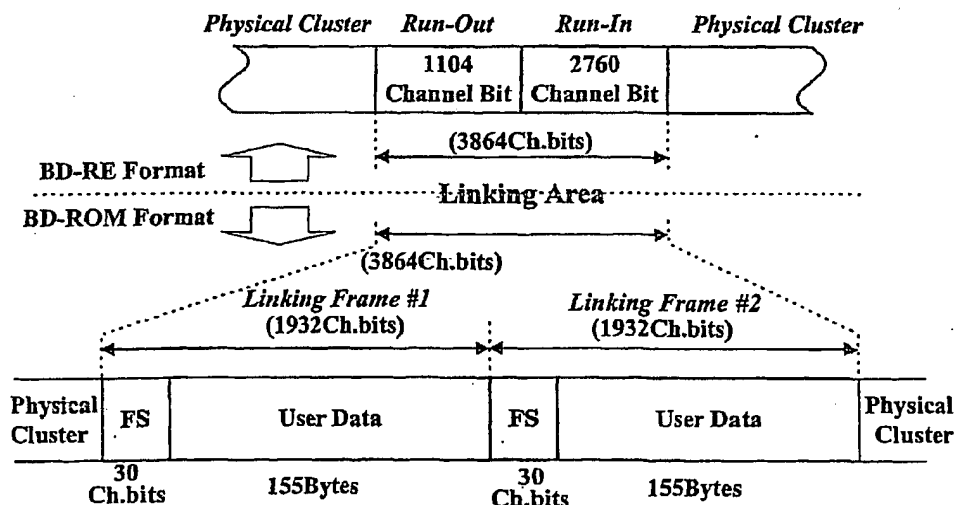
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(54) Title: **STRUCTURE OF A LINKING AREA FORMED ON A HIGH-DENSITY READ-ONLY RECORDING MEDIUM AND MANUFACTURING/REPRODUCING METHOD AND APPARATUS THEREOF**



(57) Abstract: The present invention relates to structure of a linking area formed between data sections on a high-density read-only recording medium in order to ensure reproduction compatible with a rewritable recording medium. The present structure of a linking area is composed of two linking frames including sync signals individually. This sync signal is different from other sync signal written in a data recording area and/or used for a high-density rewritable recording medium. Moreover, the linking area includes data scrambled with a physical address in its space.



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# DESCRIPTION

## STRUCTURE OF A LINKING AREA FORMED ON A HIGH-DENSITY READ-ONLY RECORDING MEDIUM AND MANUFACTURING/REPRODUCING METHOD AND APPARATUS THEREOF

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### 1. TECHNICAL FIELD

The present invention relates to structure of a linking area formed between data sections on a high-density read-only recording medium in order to be compatible with a rewritable recording medium in reproduction.

### 2. BACKGROUND ART

A disc-type recording medium such as a compact disc (CD) can store high-quality digital audio data permanently, so that it is very popular recording medium. Moreover, a digital versatile disc (referred as 'DVD' hereinafter) has been developed as a new disc-type recording medium. A DVD can store much larger size than a CD, thus, high-quality moving picture or audio data are recorded on a DVD for much longer time. Therefore, a DVD is being used widely. There are three types of a DVD, DVD-ROM for read-only, DVD-R for write-once, and DVD-RAM or DVD-R/W for rewritable.

Recently, a high-density rewritable recording medium, called BD-RE (Blu-ray Disc REwritable), larger in storage capacity than a DVD is being standardized among concerned companies.

As shown in Fig. 1a, a rewritable disc, BD-RE has divided areas composed of a clamping area 1, a transition area 2, a burst cutting area (BCA) 3, a lead-in area 4, a data zone, and

a lead-out area 5.

The clamping area 1 is a center area to be clamped by a clamper of disc device to fix a rotating disc, and the transition area 2 is an area between the clamping area 1 and the information area including the lead-in area 4 and the data zone. The BCA 3 is used to add information to the disc after completion of a disc manufacturing process. The lead-in area 4 is where important information needed to disc reproduction while the lead-out area 5 is where disc ending signal is written.

The lead-in area 4 is subdivided into several areas of the first guard, PIC, the second guard, the second information, OPC, reserved, and the first information.

The first guard area is meant as a protection area against overwriting of the PIC area by the BCA, the PIC area is an area where general information about the disc and various other information has been stored in the pre-recorded groove, the second guard area is meant as a buffering area for the changeover from the pre-recorded area to the rewritable area, and the first and the second information area are respectively used to store specific information about disc or application, such as e.g. control information.

Figs. 1b and 1c show an RUB (Recording Unit Block) defined in the disc standard under discussion. A single RUB, which is corresponding to a single ECC (Error Correction Code) block, is composed of Run-in, physical cluster, Run-out, and guard area, as shown in Fig. 1b. If many RUBs, namely, successive RUBs are created at a time to store real-time input data, e.g., A/V data, the set of Run-in, physical and Run-out is created repeatedly as many as necessary and a guard area 'Gurar\_3' is formed at the end, as shown in Fig. 1c.

The Run-in, as shown in Fig. 2a, consists of a 1100-

channel-bit guard 'Guard\_1' and a 1660-channel-bit preamble 'PrA'. 55 repetitions of a 20-channel-bit pattern are written in the guard 'Guard\_1' to indicate the head of an RUB while the first sync data 'Sync\_1' and the second sync data 'Sync\_2', which are 30 channel bits in length, are written in the preamble 'PrA'. Each sync data is composed of 24-bit sync body and 6-bit sync ID. The sync IDs of the first and the second sync data are '000 100' (FS4) and '010 000' (FS6), respectively.

The Run-out, as shown in Fig. 2b, is composed of a 540-channel-bit guard 'Guard\_2' and a 564-channel-bit post-amble 'PoA' including the third sync data 'Sync\_3'. The third sync data also consists of 24-bit sync body and 6-bit sync ID. The sync ID of the third is '000 001' (FS0).

The guard 'Guard\_2' is created to prevent overlap between previously-recorded data and new data to be recorded and it has 27 repetitions of a 20-channel-bit pattern to indicate the end of a previously-recorded area, namely, a just-recorded RUB.

User data is written in the physical cluster and it is restored to original data by a signal processor that uses a clock synchronized with sync data written in the Run-in.

Fig. 1d shows detailed recording format of a physical cluster of a BD-RE where 31 recording frames (frames #0-#30) are recorded. The mutually-different 7 frame syncs (FSs #0 to #6) are written in the 31 recording frames in a predetermined unique order, as shown in Fig. 1d.

Fig. 1e shows types and patterns of frame syncs to be written in a physical cluster. As shown in Fig. 1e, total 7 frame syncs are used and each frame sync is composed of 24-bit sync body and 6-bit sync identifying pattern which is different among 7 frame syncs.

Each RUB, corresponding to a single ECC block as aforementioned, has physical address information, e.g., address

unit number (AUN) to enable random access of an arbitrary RUB written on a BD-RE. The physical address information is written in a physical cluster of an RUB after modulated and encoded along with A/V data. And, an AUN is derived from physical  
5 sector number (PSN) that has not been written actually on a BD-RE.

In case of a write-once and a rewritable disc (DVD-R, -RW, -RAM, +R, +RW), a linking frame is created behind a previously-recorded area before new data is recorded in discontinuity with  
10 the previously-recorded data. However, a read-only disc such as DVD-ROM and video CD need not any linking frame to link two data sections because it contains completely-recorded data.

Such a difference between a writable and a read-only disc demands an ordinary disc player such as a DVD-player and DVD-  
15 ROM drive to equip with additional hardware and/or software to play back the both types of discs.

Needless to say, a disc device capable of recording/reproducing a writable disc also has to equip with additional hardware and/or software to play back a read-only  
20 disc as well as a writable disc.

In the meantime, the standard of a high-density read-only recording medium, called 'BD-ROM', is also under discussion together with the standardization of a BD-RE. By the way, if the physical format of a BD-ROM was to be same with a BD-RE a  
25 disc player would have the advantage to apply same reproduction algorithm to both recording media. In addition, there is necessity that they are distinguished as well as that their format compatibility is guaranteed. Therefore, it is necessary to harmonize these mutually contrary conditions. Nevertheless,  
30 suitable harmonizing solutions are not provided yet.

### 3. DISCLOSURE OF INVENTION

It is an object of the present invention to provide a

read-only recording medium that has the same physical recording format including a linking area in order to guarantee reproduction compatibility with a high-density rewritable recording medium, and to provide method and apparatus for  
5 reproducing said read-only recording medium.

It is another object of the present invention to provide a read-only recording medium with sync data in a linking area whose bit pattern is different from sync data written in data recording area, and to provide method and apparatus for  
10 reproducing said read-only recording medium.

It is another object of the present invention to record a physical address in a linking area along with a frame sync.

It is another object of the present invention to provide a read-only recording medium with a linking area where  
15 scrambled data is written, and to provide method and apparatus for reproducing said read-only recording medium.

It is another object of the present invention to provide a read-only recording medium whose linking area includes data scrambled the same manner as main data, and to provide method  
20 and apparatus for reproducing said read-only recording medium.

It is another object of the present invention to provide a read-only recording medium whose linking area includes data scrambled by using values derived from physical sectors associated with data frames within a previous physical cluster,  
25 and to provide method and apparatus for reproducing said read-only recording medium.

It is another object of the present invention to provide a read-only recording medium including dummy data in its linking areas, and to provide method and apparatus for  
30 reproducing said read-only recording medium.

It is another object of the present invention to provide a read-only recording medium whose linking area includes data

recorded in a error-recoverable format, and to provide method and apparatus for reproducing said read-only recording medium.

A read-only recording medium and reproducing method and apparatus thereof in accordance with the present invention is  
5 characterized in that a linking area is created at an area corresponding to Run-in and Run-out area of a rewritable recording medium.

It is further characterized in that a predetermined-sized recording frame is written in the linking area.

10 It is further characterized in that useful information is written in the recording frame.

It is further characterized in that it a linking area is formed every junction between recorded data sections wherein each linking area includes at least one sync signal indicative  
15 of linking area.

It is further characterized in that the sync signal written in a linking area is different from a sync signal written in the data section.

It is further characterized in that each of the linking  
20 areas includes data scrambled by a physical address written adjacently before or after the linking area.

It is further characterized in that the linking area includes data scrambled by a frame sync written therein.

It is further characterized in that the linking area  
25 includes data scrambled by an arbitrary pre-defined value.

It is further characterized in that dummy data is recorded in a recording frame within a linking area.

It is further characterized in that information indicative of physical address is also written in the recording  
30 frame.

It is further characterized in that user data is written in the form of ECC block in the recording frames.



It is further characterized in that data is written in the recording frame within the linking area after processed in the same or similar manner as user data in a data frame is done.

It is further characterized in that a certain area of 5 data area, where an RUB is to be written, corresponding to Run-in and Run-out area of a rewritable recording medium is written with a predetermined-sized recording frame.

It is further characterized in that a certain area corresponding to Run-in and Run-out area of a rewritable 10 recording medium is written with predetermined-sized recording frames, wherein a frame sync having a unique bit pattern is written in at least one recording frame.

It is further characterized in that a certain area of data area, where an RUB is to be written, corresponding to Run- 15 in and Run-out area of a rewritable recording medium is written with predetermined-sized recording frames where a frame sync having a unique bit pattern is twice or more.

It is further characterized in that a certain area of data area, where an RUB is to be written, corresponding to Run- 20 in and Run-out area of a rewritable recording medium is written with predetermined-sized recording frames, wherein a frame sync having a unique bit pattern is written in at least one recording frame.

A method of reproducing data in a linking area of a read- 25 only recording medium in accordance with the present invention is characterized in that it comprises the steps of: reading a frame sync included in a recording frame of a read-only recording medium and checking a sync identifying pattern in the read frame sync; and determining a current area to a linking 30 area if the checked pattern is different from those of frame syncs written in a physical cluster.

A method of recording useful data on a read-only

recording medium in accordance with the present invention is characterized in that it records predetermined-sized recording frames in a certain area corresponding to Run-in and Run-out area of a rewritable recording medium, and further records in  
5 the recording frames address information about a physical cluster before or behind the recording frames.

The recording method is further characterized in that it records predetermined-sized recording frames in a certain area corresponding to Run-in and Run-out area of a rewritable  
10 recording medium, and further records useful information in user data spaces of the recording frames.

The recording method is further characterized in that it records a recording frame, which includes a sync, a physical address and user data, in a linking area corresponding to Run-  
15 in and Run-out area of a rewritable recording medium, wherein the user data is scrambled by one of the sync and the address included therein, a preset value, and an AUN written in a physical cluster closest to the recording frame.

The recording method is further characterized in that it  
20 records recording frames, each including a sync, a physical address and user data, in a linking area corresponding to Run-in and Run-out area of a rewritable recording medium, and further records different preset dummy data in a user data space of each recording frame.

#### 25 4. BRIEF DESCRIPTION OF DRAWINGS

The above features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

30 Fig. 1a shows the structure of a rewritable disc BD-RE (Blu-ray Disc REwritable);

Figs. 1b and 1c show respective formats of a recording

unit block of a BD-RE;

Fig. 1d shows the structure of a physical cluster of a BD-RE;

Fig. 1e shows frame syncs used for a BD-RE;

5 Figs. 2a and 2b show respectively Run-in and Run-out area included in a recording unit block of a BD-RE;

Figs. 3a and 3b show respective formats of Run-in and Run-out area formed in a recording unit block of a BD-ROM in accordance with the first embodiment of the present invention;

10 Fig. 4a shows format of a linking area structured in a BD-ROM in accordance with the second embodiment of the present invention;

Fig. 4b shows format of a linking area structured in a BD-ROM in accordance with the third embodiment of the present  
15 invention;

Fig. 4c shows format of a linking area structured in a BD-ROM in accordance with the fourth embodiment of the present invention;

Fig. 4d shows format of a linking area structured in a  
20 BD-ROM in accordance with the fifth embodiment of the present invention;

Fig. 5 shows new frame syncs defined in accordance with the present invention;

Fig. 6a shows the structure of a linking area to link  
25 physical clusters that is formed on a BD-ROM and applicable frame syncs in accordance with an embodiment of the present invention;

Fig. 6b illustrates frame syncs to be used for linking frames in accordance with the present invention;

30 Figs. 7a to 7c show respective structures of each linking frame in a linking area and illustrate frame syncs written therein in accordance with the present invention;

Fig. 7d is a conversion table of 17PP modulation;

Fig. 8 is a flow diagram to reproduce each linking frame in accordance with the present invention;

Fig. 9 is a simplified block diagram of a player to play  
5 a recording medium;

Figs. 10a to 10c show schematically respective manners to write a physical address in a linking area in accordance with the present invention;

Fig. 11a is a block diagram of a linking frame  
10 constructing circuitry to create a linking frame with input user data as structured in Fig. 4a;

Fig. 11b is a block diagram of a linking frame constructing circuitry to create a linking frame with input user data as structured in Fig. 4d;

15 Fig. 12a shows structure of a physical address allocated in the linking frame structured as Fig. 4b;

Fig. 12b is a detailed block diagram of a scrambler to scramble user data into the linking frame structured as Fig. 12a;

20 Fig. 13 is a detailed block diagram of a scrambler to scramble user data into the linking frame structured as Fig. 4c;

Figs. 14a to 14c illustrate individually user data spaces of linking frames where user data of arbitrary values are  
25 written;

Fig. 15a shows an embodiment of the present invention to write user data in error recoverable format in a user data space of a linking frame structured as Fig. 4d;

Fig. 15b shows a useful data recording case in the ECC  
30 format in the embodiment of Fig. 15a;

Fig. 15c shows a small-sized useful data recording case in the ECC format in the embodiment of Fig. 15a; and

Fig. 16 shows another embodiment to write user data in error recoverable format in a user data space of a linking frame according to the present invention.

## 5. MODES FOR CARRYING OUT THE INVENTION

5 In order that the invention may be fully understood, preferred embodiments thereof will now be described with reference to the accompanying drawings.

First, a linking area of a high-density recording medium structured in accordance with the present invention and data  
10 recording manners related with the linking area, namely, data forming manners are explained in detail.

Hereinafter, the terms of 'write', 'record' and 'form' are used to represent same meanings for a read-only recording medium. And, a frame formed in the linking area is called  
15 linking frame or recording frame.

### (1) Structure of a linking area

A high-density read-only recording medium, e.g., a BD-ROM structured in accordance with the present invention has a  
20 physical format (composed of Run-in, physical cluster, Run-out, and guard) that was described with reference to Figs. 1 and 2 for a high-density rewritable recording medium. However, The respective fields of a BD-ROM corresponding to the format elements of a rewritable recording medium can be named  
25 differently.

The Run-in formed by the first embodiment of the present invention is, as shown in Fig. 3a, composed of a guard 'Guard\_1' and a preamble 'PrA' that includes two sync data. Each sync data consists of 24-bit sync body and 6-bit sync ID.

30 While sync IDs of sync data in a preamble of a BD-RE are respectively '000 100' and '010 000' as shown in Fig. 2a, the preamble of a BD-ROM structured in accordance with the present

invention includes two sync data whose IDs are FS0('000 001') (Sync\_3) and FS6('010 000') (Sync\_2). The sync data 'Sync\_3' is placed ahead of the sync data 'Sync\_2'.

In addition, the post-amble 'PoA' in Run-out of a BD-ROM  
5 structured in accordance with the present invention, as shown in Fig. 3b, includes sync data whose ID is FS4('000 100') (Sync\_1). This is different from a BD-RE in that sync data with sync ID of FS0('000 001') is written in the post-amble of a BD-RE.

10 In case of a BD-RE, if two RUBs are created a pair of Run-in and Run-out is formed as illustrated in Fig. 1c. This pair of Run-in and Run-out (that corresponds to a linking area) includes three sync data whose recording order is 'Sync\_1', 'Sync\_2' and 'Sync\_3'. By the way, the recording order of the  
15 BD-ROM is 'Sync\_3', 'Sync\_2' and 'Sync\_1' which is reverse order of a BD-RE.

Consequently, although the BD-ROM structured in accordance with the present invention is same in physical recording format with a BD-RE it can be distinguished from a  
20 BD-RE because of sync data written order in a linking area. In addition, whether or not a current area is linking area of a BD-ROM is easily determined based on arrangement of the sync data.

In the above embodiment, the Run-in, Run-out and the  
25 guard 'Guard\_3' may include information similar to the recorded on corresponding areas of a BD-RE.

The structure of a linking area of the BD-ROM can be differently defined as depicted in Fig. 4a that illustrates the second embodiment of the present invention. As shown Fig. 4a,  
30 in case of a BD-ROM, two linking frames of same size (1932 channels bits) constitute a single linking area while, in case of a BD-RE, 1104-bit Run-in and 2760-bit Run-out, which are

different in size, constitute a single linking area.

The two linking frames are in same structure and each frame is composed of 30-channel-bit frame sync, 9-byte physical address, 114-byte user data, and 32-byte parity.

5       The 114-byte user data may include a variety of additional information, e.g., anti-piracy information that makes it impossible to illegally copy contents such as a movie recorded on a BD-ROM to other medium, or control information to be used for a servo-control operation.

10       Fig. 4b illustrates the third embodiment of the present invention. The linking area in the third embodiment is composed of two same-sized (1932 channel bits) linking frames and each frame is composed of a 30-channel-bit frame sync, 9-byte physical address, 146-byte user data. Compared with Fig. 4a,  
15 the embodiment of Fig. 4b is different in that it has no parity.

Useful information can be written in the 146-byte user data space. The useful information is anti-piracy information that makes it impossible to illegally copy contents such as a movie recorded on a BD-ROM to other medium, or control  
20 information to be used for a servo-control operation.

Fig. 4c illustrates the fourth embodiment of the present invention. The linking area in the fourth embodiment is composed of two same-sized (1932 channel bits) linking frames and each frame is composed of a 30-channel-bit frame sync, and  
25 155-byte user data. Compared with Fig. 4a, the embodiment of Fig. 4c is different in that it has no physical address and no parity. This embodiment is also different from that of Fig. 4b in that it has no physical address.

Fig. 4d illustrates the fifth embodiment of the present  
30 invention. The linking area in the fifth embodiment is composed of 30-channel-bit leading frame sync, 3714-channel-bit linking part, two 30-channel-bit rear syncs, and two repetition

patterns that are 40 and 20 channel bits long, respectively.

The 3714-channel-bit linking part is composed of three linking frames, and 4-bit dummy data.

A linking area can have any possible structure different from the above described.

Data is written in the form of ECC block in the physical cluster and the aforementioned seven frame syncs FS0-FS6 are used in an ECC block in general.

At least one linking frame of the two shown in Fig. 4a uses new frame sync 'FS n' that is different in sync ID from the seven frame syncs. The sync ID of this new frame sync 'FS n' is '100 101' (FS7), '101 010' (FS8), '010 101' (FS9), or '101 001' (FS10) as shown in Fig. 5.

All of the four sync candidates satisfy a constraint that transition shift, which is specified for a BD-RE, is not shorter in bit pattern than 2 bits.

In the recording embodiment of Fig. 4a, the frame sync FS0 is written in the first linking frame, and the frame sync 'FS n' in the second.

By the way, data recording onto a BD-ROM must satisfy 'Prohibit RMTR (Run-Limited TRAnsition)' constraint of 17PP (Parity Preserve) modulation code that is data recording standard defined for a BD-RE.

The Prohibit RMTR constraint, which is to ensure stable detection of RF signal, is that minimum run length 2T, namely, '01' or '10' must not be repeated continuously more than six times. Therefore, it is preferable to use a frame sync with small transition frequency, namely, '100 101' (FS7) or '101 001' (FS10) among the new frame syncs to make successive bit trains satisfy the constraint. The usage of frame syncs is explained in detail with reference to Fig. 6.

The first case illustrated in Fig. 6b is the first



embodiment of the present invention. In this embodiment, two 1932-channel-bit recording frames are recorded in a linking area and each recording frame is composed of a frame sync, a physical address, user data, and parity. At least one of the two recording frames includes the newly-defined frame sync 'FS n'.

For instance, the frame sync 'FS0' with its identifying pattern (ID) '000 001' is written as the first frame sync while the new frame sync 'FS n' whose sync identifying pattern is '010 101', '101 010', or '100 101' is written in the second.

In the event that the new frame sync 'FS n' whose sync identifying pattern is '010 101', '101 010', or '100 101' is used, the 9-byte physical address following the frame sync 'FS n' has an unscrambled starting data '00' as illustrated in Fig. 6a. This is because it is advantageous to satisfy the RMTR constraint of 17PP modulation codes defined for data recording on a BD-RE.

For example, if the new frame sync FS7 with sync identifying pattern of '100 101' is used and, at the same time, the following user data bits are "01 11 01 11" whose modulated bits by 17PP modulation table given in Fig. 7d are "010 101 010 101", the final modulated bits including the sync identifying pattern constitute "100 101 010 101 010 101" where 2T pattern, the pattern of one zero between neighboring two ones, arises continuously seven times.

However, if user data includes '00' at its head, the above user data example becomes "00 01 11 01 11" whose 17PP modulated bit train is "010 100 101 010 101". Therefore, the final bits with the sync identifying pattern constitute "100 101 010 100 101 010 101" where three 2T patterns, a 3T and four 2T patterns arise sequentially.

The second case illustrated in Fig. 6b is the second

embodiment of the present invention. In this embodiment, two 1932-channel-bit recording frames are recorded in a linking area and each recording frame is composed of a frame sync, a physical address, user data, and parity. At least one of the  
5 two recording frames includes the frame sync FS10('101 001'), one of the newly-defined frame sync 'FS n'.

For instance, the frame sync FS0 with its identifying pattern '000 001' is written as the first frame sync while the new frame sync FS10 whose sync identifying pattern is '101 001'  
10 is written in the second.

In the event that the new frame sync 'FS10' is used, the RMTR constraint of 17PP modulation codes defined for data recording on a BD-RE is automatically satisfied. Consequently, the following physical address has not to be started with '00'.

15 For example, if the new frame sync 'FS10' with sync identifying pattern of '101 001' is used and, at the same time, the following user data bits are "01 11 01 11" whose modulated bits by 17PP modulation table given in Fig. 7d are "010 101 010 101", the final modulated bit train with the sync identifying  
20 pattern constitutes "101 001 010 101 010 101" where one 2T, one 3T and six 2T patterns arise.

The third case illustrated in Fig. 6b is the third embodiment of the present invention. In this embodiment, two 1932-channel-bit recording frames are recorded in a linking  
25 area and each recording frame is composed of a frame sync, a physical address, user data, and parity. The both recording frames include the newly-defined frame sync 'FS n'.

For instance, the first and the second frame sync use one of the new frame syncs FS7('010 101'), FS8('101 010'), and  
30 FS9('100 101').

In the event that the new frame sync FS7, FS8 or FS9 is used, a physical address of 9 bytes following the frame sync

FS7, FS8 or FS9 has an unscrambled starting data '00' as illustrated in Fig. 6a. This is, as explained before, to satisfy better the RMTR constraint of 17PP modulation codes defined for data recording on a BD-RE.

- 5        In case that the new frame sync FS7('100 101') is used, the RMTR constraint can be satisfied by writing user data space following the frame sync having data other than "01 11 01 11".

      The fourth case illustrated in Fig. 6b is the fourth embodiment of the present invention. In this embodiment, two  
10 1932-channel-bit recording frames are recorded in a linking area and each recording frame is composed of a frame sync, a physical address, user data, and parity. The both recording frames include the new frame sync FS10('101 001').

      In the event that the new frame sync 'FS10' is used for  
15 both data frames, the RMTR constraint of 17PP modulation codes defined for data recording on a BD-RE is automatically satisfied. Consequently, the physical address following each frame sync has not to be started with bits '00'.

      If the newly-defined frame sync 'FS n' is used as  
20 explained above, whether a current area is within a linking area or not is determined very easily and accurately because the new frame sync is different from those used in a physical cluster.

      For example, in case that frame sync combination is used  
25 to determine a current area, because a frame sync combination made from 'FS n' written in a linking area and FS4, FS4, and FS2 written respectively in the 29th to the 31st recording frames (Recording Frames #28 to #30) within a previous physical cluster becomes FSn-FS4 or FSn-FS2 which is obviously different  
30 from a combination made from frame syncs written in a physical cluster, whether a current area is within a linking area is determined accurately based on the frame sync combination.

The above explained several cases are summarized as follows.

If adequate constraint is imposed to data to be written just after a frame sync, any of the four frame syncs can be  
5 used.

For instance, in case that a physical address is written behind a frame sync, if the physical address always has a header of bits '00' the frame syncs FS8 and FS9 can be used with no trouble.

10 In even case that a physical address is not written, if a certain byte, e.g., '08h' (0000 1000) is written without being scrambled just behind a frame sync, a bit train "000 100 100 100" modulated from '08h' by the 17PP modulation is placed after a frame sync, so that any of the four new frame syncs  
15 FS7-FS10 can be used irrespective of RMTR constraint.

Frame syncs are used such that one of the four new frame syncs FS7-FS10 is written in a linking frame of the two while one of the already-known frame syncs FS0-FS6 is in the other linking frame. Needless to say, the new frame syncs only can be  
20 used in both of linking frames as shown in the cases 3 and 4 of Fig. 6.

In case that at least one selected from the new frame sync 'FS n' is used in a linking frame, a disc player, that consists of an optical pickup 11, a VDP system 12, and a D/A  
25 converter 13 as depicted in Fig. 9, is able to know very fast whether a currently-read frame is within a linking area or a data section (physical cluster) while reproducing recorded data from a BD-ROM.

In case of a BD-RE, 31 recording frames individually  
30 include one of seven different frame syncs. However, seven frame syncs are not enough to define 31 recording frames distinguishably, so that a frame sync in the previous recording

frame or frames is used to identify a current recording frame along with a frame sync in the current frame.

In other words, a recording frame N can be identified by successive syncs of its own frame sync and the frame sync in the previous recording frames N-1, N-2, and/or N-3. That is, although one or two previous syncs N-1 and/or N-2 are not detected, the last-detected sync N-3 can be used to identify the recording frame N along with its sync.

For instance, supposing that a current recording frame is the seventh, namely, recording frame #6, its frame sync is FS1 as shown in Fig. 1d.

However, the frame sync FS1 is also written in the frames #1, #23, and #24, so that previously-detected frame sync is used to identify the current frame. The currently-detected frame sync FS1 and the previously-detected frame sync or syncs FS4, FS1, and/or FS3, which are respectively in the frames #5, #4, and #3, enable the current frame to be identified to the seventh.

Because arrangement of frame syncs is used to identify a data frame as explained above, frame sync sequence from a previous data frame to a recording frame within a linking area using the newly-defined frame sync should be considered. This is explained in detail with reference to Figs. 7a to 7c.

Figs. 7a to 7c show applicable frame sync sequences in accordance with the present invention.

Fig. 7a is for the first case shown in Figs. 6a and 6b and Figs. 7b and 7c are respectively for a sync pair of FS7-FS7 and FS7-FS8 of the third case shown in Fig. 6b.

In case that frame syncs of FS0 and FS7 are used as given in Fig. 7a, the frame syncs of frames N, N-1, and N-3 before the frame #0 with frame sync FS0 are FS7, FS0 and FS2 sequentially as the case (1) shows. This frame #0 is

corresponding to the first address unit of an RUB. As the case (2) shows, three frames before the frame #0 at the second row have frame syncs of FS2, FS4 and FS4, sequentially. This frame #0 is corresponding to the middle address unit of an RUB. As the case (3) shows, three frames before the frame #1 have frame sync sequence of FS0, FS7/FS2 and FS4, so that this frame #1 is corresponding to the first address unit or the middle unit of an RUB. In addition, the three frames before the frame #2 are FS1, FS0 and FS7/FS2 sequentially in their frame syncs as the case (4) shows, so that this frame #2 is corresponding to the first or the middle unit of an RUB.

As depicted in the 'A'-marked case of Fig. 7a, both of the frame #0 corresponding to the middle address unit of an RUB and the frame #31 (the first linking frame) proposed newly in accordance with the present invention have same frame sync sequence of previous frames. Therefore, it would be difficult to detect start of a linking area, and the adoption of the pair of FS0 and FS7 would not be an adequate solution.

Next case that only FS7 is used as given in Fig. 7b is explained. As given in the case (1) of Fig. 7b, the frame sync sequence before the frame #0 is FS7/FS2, FS7/FS4 and FS2/FS4 and the frame #0 is the first address unit or the middle unit of an RUB. As the case (2) shows, the frame sync sequence before the frame #1 is FS0, FS7/FS2 and FS7/FS4 and the frame #1 is the first or the middle unit of an RUB. In addition, as the case (3) shows, the frame sync sequence before the frame #2 is FS1, FS0 and FS2 and the frame #2 is also the first or the middle unit of an RUB.

However, as depicted in the 'B'-marked case of Fig. 7b, the first linking frame (frame #31) and the second (frame #32), which are newly proposed in accordance with the present invention, have same frame sync sequence at frames N and N-3,

which might cause a problem in defining a linking area. However, because two linking frames have newly-defined frame sync FS7 in case of use of two FS7s, this case of FS7-FS7 would cause less severe problem in detecting a linking area than the case of 5 FS0-FS7 of Fig. 7a.

Fig. 7c shows the case that FS7 and FS8 are used. As the case (1) shows, the frame sync sequence ahead of the frame #0 is FS8/FS2, FS7/FS4 and FS2/FS4 and the frame #0 is the first or the middle address unit of an RUB. As the case (2) shows, 10 the frame sync sequence before the frame #1 is FS0, FS8/FS2 and FS7/FS4 and the frame #1 is the first or the middle unit of an RUB.

In addition, as the case (3) shows, the frame sync sequence ahead of the frame #2 is FS1, FS0 and FS7/FS2 and the 15 frame #2 is also the first and the middle unit of an RUB.

As shown in Fig. 7c, the use of FS7 and FS8 dose not reveal same previous frame sync sequence before any frame, namely, the previous frame sync sequence before any frame is unique, therefore, it causes no problem in detecting a linking 20 area contrary to the two cases of Figs. 7a and 7b.

Consequently, the use of FS7 and FS8 is the best for a linking area structured in accordance with the present invention. In addition, the frame syncs FS7 and FS8 satisfy RMTR constraint as explained before.

25 Fig. 8 is a flow diagram of an embodiment of a method to reproduce a recording medium structured in accordance with the present invention.

If a BD-ROM containing a linking area structured in accordance with the present invention is loaded (S81), 30 management information for reproducing control written in the BD-ROM is read into a memory first (S82). Because the management information has been written in a lead-in area in

general, it is read out at an initial preparing stage by an optical pickup. Afterwards, reproduction of main data is started under control of a controlling unit (S83). During the reproduction, it is checked whether a frame sync is detected  
5 (S84). If detected, it is determined whether or not the detected sync is one of syncs written in main data area (S85). This determination is possible if a disc recording/reproducing device having syncs FS0-FS8 stored therein compares the detected sync with the stored ones.

10 If it is determined that the detected sync is one of syncs (FS0-FS6) written in the main data area (S86), reproduction continues. However, if it is determined that the detected sync does not pertain to one of syncs (FS0-FS6), which means that it is a newly-defined sync FS7 or FS8, a current  
15 location is regarded a linking area (S87) and then whether within the first linking frame or within the second is re-checked (S88). If within the first linking frame, data following its frame sync is descrambled out (S89). Otherwise, the current location is regarded the second linking frame and  
20 then data just after its frame sync is descrambled out (S90).

Therefore, a disc player, that consists of an optical pickup 11, a VDP system 12, and a D/A converter 13 as depicted in Fig. 9, can detect more accurately a physical address and user data within the first and the second linking frame  
25 (Recording Frames #k+1, #k+2) of a BD-ROM when it is placed therein. Especially, if the user data contains useful information for anti-piracy or servo-control, the disc play conducts an operation suitable to the useful information.

As explained above, whether a current location, which an  
30 optical pickup is on, is within a linking area or main data area can be known easily and fast through detecting and comparing newly-defined frame sync.



## (2) Physical Address

In the linking frame structure shown in Fig. 4a, there are three cases in writing a physical address in each recording frame of a linking area as shown in Fig. 10a. The first case writes in both linking frames an AUN of a physical cluster #k+1 closest behind the frames, and the second case writes an AUN of a physical cluster #k closest before the frames.

In the third case, an AUN of a physical cluster #k closest before the first linking frame is written in the first while an AUN of a physical cluster #k+1 closest behind the second linking frame is written in the second.

The physical address, composed of 4-byte address, 1-byte reserved and 4-byte parity as shown in Fig. 11a, is encoded to have error recovery capability by RS(9,5,5) that is used for a BD-RE. The processing to make an address have error recovery capability will be described in detail later.

Therefore, a disc player, that consists of an optical pickup 11, a VDP system 12, and a D/A converter 13 as depicted in Fig. 9, can detect more accurately a physical address and user data within the first and the second linking frame (Recording Frames #k+1, #k+2) of a BD-ROM when it is placed therein. Especially, if the user data contains useful information for anti-piracy or servo-control, the disc play conducts an operation suitable to the useful information.

In the linking frame structure shown in Fig. 4d, there are two cases in writing a physical address in each of three recording frames of a linking area as shown in Fig. 10b. The first case writes in three linking frames an AUN of a physical cluster #k+1 closest behind the frames, and the second case writes an AUN of a physical cluster #k closest before the frames.

The physical address, composed of 4-byte address, 1-byte reserved and 4-byte parity as shown in Fig. 11a, is encoded to have error recovery capability by RS(9,5,5) that is used for a BD-RE. The processing to make a physical address have error recovery capability will be described in detail later.

Therefore, a disc player, that consists of an optical pickup 11, a VDP system 12, and a D/A converter 13 as depicted in Fig. 9, can detect more accurately a physical address and user data within the successive three linking frames (Recording Frames #k+1, #k+2, #k+3) of a BD-ROM when it is placed therein. Especially, if the user data contains useful information for anti-piracy or servo-control, the disc play conducts an operation suitable to the useful information.

Fig. 10c shows another embodiment of the present invention that writes an address in a recording frame. Each of the linking frames (Recording Frames #k+1, #k+2) contains a 9-byte physical address where 4-byte actual address is included. The 4-byte actual address may have same value with 16 AUNs #0~#15 written in a physical cluster before or behind the linking frames.

A 4-byte actual address written in a physical cluster before the first linking frame is composed of a 27-bit address, a 4-bit sequence number (0000~1111) indicative of its order in physical addresses and 1-bit fixed value '0', as shown in Fig. 10c. All of the 27-bit addresses written in the leading physical cluster has same value.

Another 4-byte actual address written in a physical cluster behind the second linking frame is composed of a 27-bit address, a 4-bit sequence number (0000~1111) indicative of its order in physical addresses and 1-bit fixed value '0', as shown in Fig. 10c. All of the 27-bit addresses written in the following physical cluster has same value.

As aforementioned, the 4-byte actual address of the first linking frame includes an address written in the physical address located therebefore. For example, the 4-byte actual address of the first linking frame has the address value of the closest 16-th AUN (AUN #15) of 27-bit and '11110', as shown in Fig. 10c. In this case, the last 1-bit '0' of the five bits '11110' to be written in the first linking frame can be replaced with '1' in order to indicate that a physical address is one written in a linking area other than a physical cluster.

10 In addition, the 4-byte actual address of the second linking frame includes an address written in the physical address located thereafter. For example, the 4-byte actual address of the second linking frame has the address value of the closest first AUN (AUN #0) of 27-bit and '00000', as shown  
15 in Fig. 10c. In this case, the last 1-bit '0' of the five bits '00000' to be written in the second linking frame can be replaced with '1' in order to indicate that a physical address is one written in a linking area other than a physical cluster.

The final five bits of the 4-byte actual address to be  
20 written in the first linking frame may be '00000' while the final five bits to be written in the second linking frame may be '11110'.

In addition, an address written in an arbitrary physical cluster among physical clusters located before or after a  
25 linking area can be written in the first and the second linking frame as explained before with reference to Fig. 10c.

### (3) Scrambling

Fig. 11a is a block diagram of a linking frame  
30 constructing circuitry for the structure shown in Fig. 4a. The linking frame constructing circuitry comprises a scrambler 10 and an adder 20. The scrambler 10 scrambles 114-byte user data

with 9-byte physical address to make its DSV (Digital Sum Value) close zero and adds the 9-byte physical address before the scrambled user data.

The adder 20 adds 32-byte parity behind the address-added user data from the scrambler 10 as well as a 20-channel-bit frame sync ahead of the address-added user data. Consequently, a complete recording frame including 114-byte user data scrambled with a 9-byte physical address is constructed.

In the scrambling of user data, information other than a 9-byte physical address can be used.

Fig. 11b is a block diagram of another linking frame constructing circuitry for the structure shown in Fig. 4d. This linking frame constructing circuitry comprises a scrambler 10' and an adder 20'. The scrambler 10' scrambles 62-byte user data such as anti-piracy information with a 9-byte physical address to make its DSV (Digital Sum Value) close zero and adds the 9-byte physical address before the scrambled user data.

The adder 20' adds 32-byte parity behind the address-added user data from the scrambler 10'. Consequently, a complete 103-byte recording frame including 62-byte user data scrambled with a 9-byte physical address is constructed.

In the scrambling of user data, information other than a 9-byte physical address can be used.

Instead of constructing a linking frame including a frame sync, 9-byte physical address, 114-byte user data, and 32-byte parity as shown in Fig. 4a, a linking frame may be constructed to have a frame sync, 9-byte physical address including 1-byte reserved and 4-byte parity, and 146-byte user data as shown in Fig. 4b or 12a. The 146-byte user data may be scrambled and the 4-byte actual physical address may be used as a scrambling key.

That is, a part of 32 bits (Add 0-Add 31) of the 4-byte physical address is used as an initial loading value of a 16-

bit shift register 101 in the scrambling circuitry, as shown in Fig. 12b. After the initial loading value is loaded in parallel into the shift register 101, one scrambling byte is outputted every bit shift.

5        Because the user data is 146-byte in length in the embodiment of Fig. 9, the part of physical address is loaded in parallel into the shift register 101 every 146 shifts. The partial address to be loaded changes as a linking area does. After the parallel loading, 146 scrambling bytes (S0-S145) are  
10        created and OR-ed exclusively with successive 146 bytes (D0-D145) of user data by an exclusive-OR gate 102, sequentially. The successive 146 bytes scrambled as before are written in a linking frame.

      Instead of a physical address, a part of frame sync  
15        pattern or some repetitions of bits '10' can be used as a scrambling key to scramble user data. Moreover, instead of a physical address to be written in a linking frame, one address among 16 addresses included in a physical cluster before or behind a current linking frame may be used. Especially, one  
20        address closest to a current linking frame is used among the 16 addresses.

      A physical address to be written in a linking frame may be scrambled along with user data written therein.

      In another embodiment of the present invention, a  
25        physical address may not be written in a linking frame as shown in Fig. 4c. In this case, a physical address before or behind a linking frame is used as a scrambling key, namely, an initial loading value to the shift register. Because user data is 155 bytes long in this embodiment, same or different physical  
30        address is loaded as an initial value into the shift register every 155 shifts.

      As shown in Fig. 13, a part of the 4-byte address (Add

#0~#31) is loaded in parallel into a 16-bit shift register 101' of a scrambler that is also applicable to a BD-RE recording and then 155 8-bit scrambling bytes (S0-S154) are outputted sequentially during the process of bit-shifts.

5       The successive 155 scrambling bytes (S0-S154) are exclusive-ORed with successive 155 user bytes (D0-D154) by an exclusive-OR gate 102'. As a result, 155 scrambled user data (D'0-D'154) are produced and they are written in a recording frame in a linking area.

10       Instead of a physical address, a part of frame sync pattern or some repetitions of bits '10' can be used as a scrambling key to scramble user data.

#### (4) Dummy Data

15       In case that useful data for anti-piracy or servo-control is not written in the user data space although two recording frames are formed in a linking area of a BD-ROM to ensure reproducing compatibility with a BD-RE, the user data space may be filled with an arbitrary certain value, e.g., '00h' as shown  
20 in Fig. 14a. A series of such a filling value is called dummy data.

If same data was filled in entire user data spaces the manufacturing process of a BD-ROM could be simplified more. By the way, if adjacent tracks had same bit patterns crosstalk  
25 would arise. Thus, as another embodiment of dummy data, several values, e.g., '00h', '01h', '10h', '11h', 'FFh', 'AAh', etc. are written in user data spaces by turns as illustrated in Fig. 14b in order to reduce probability of crosstalk.

In this embodiment of dummy data recording, dummy data of  
30 different values are recorded in the recording frames of each linking frame allocated in a BD-ROM, which reduces the probability that same recording patterns are formed between

neighboring tracks. Consequently, the crosstalk probability is reduced remarkably.

In case that two recording frames are formed in a linking area of a BD-ROM to ensure reproducing compatibility with a BD-RE, as another embodiment according to the present invention, the user data space may be filled with arbitrary several different values, e.g., '00', '01', '11' which appear alternately as shown in Fig. 14c.

In the dummy data recording embodiment of Fig. 14c, a linking area has same data in their user data spaces while neighboring linking areas have different dummy data.

In this embodiment, the probability that same recording patterns are formed between neighboring tracks is very low, therefore, the crosstalk probability is reduced compared with the embodiment of Fig. 14a. The manufacturing process of a BD-ROM of this embodiment is simpler than that of Fig. 14b.

In addition, if one value, e.g., '00h' fills entire user data spaces after scrambled with a physical address that changes every linking area, crosstalk can be eliminated remarkably too.

In case that '00h' fills the user data spaces after scrambled, if a non-scrambled '08h' is placed at the foremost front of each user data space, any of the aforementioned new frame syncs can be used irrespective of the RMTR constraint specified in 17PP modulation as explained before..

#### (5) Construction of ECC Block

If useful and important information is written in the user data space, it is channel-encoded to ensure its reliability. RS(62,30,33) and RS(248,216,33) encoding system are used as the channel encoding method. Those encoding systems have been also specified to be used to encode user data to be

written in physical clusters of a BD-ROM.

Fig. 15a shows a recording example in which data is recorded in a linking area structured in Fig. 4d. For recording useful data as illustrated in Fig. 15a, 30-byte useful data is encoded first by RS(62,30,33) system, which creates 32-byte parity.

For this operation, input data is sequentially stored in a memory to organize a 30x309 data block. When a 30x309 data block is organized, every column is sequentially scanned (151).  
10 A 32-byte parity is produced by RS(62,30,33) encoding system every one scan of the column and it is appended thereto. As a result, a 62-byte data series is constructed.

Each 62 bytes including the parity may be scrambled. In case of scrambling, a part of a physical address may be used as  
15 a scrambling key as explained before.

Next, a 9-byte physical address is added in front of the 62 bytes made from the above process. The 9-byte physical address may be composed of an actual physical address and parity thereof. For instance, The 9-byte physical address may  
20 be composed of a 4-byte actual address, 1-byte reserved, and a 4-byte parity.

And, 145-byte dummy data is added to the 71 bytes including the physical address and then encoded by RS(248,216,33) system, as a result, 32-byte parity is added.  
25 Finally, the added 145 dummy bytes are then removed to produce a 103-byte data unit to be written in a linking area.

The above-explained operations are repeatedly conducted to next 30-byte useful data to produce successive 103-byte data units. After three units are made, 4 dummy bits are added  
30 behind the three units and total 2467 bits are then 17PP-modulated. After 17PP-modulation, the 2467 bits are extended to 3714 channel bits. The first frame sync of 30 channel bits is



placed in front of the modulated 3714 bits, and the second 30-channel-bit frame sync, a 40-channel-bit repeated bit pattern, the third 30-channel-bit frame sync, and another 20-channel-bit repeated bit pattern are sequentially appended to the modulated 5 bits. The thusly-made 3864 channel bits are written in a linking area.

In case that useful data is small not enough to fill a single linking area as above, dummy data is added to a segment of useful data to constitute 30 bytes. For instance, in case 10 that 3-byte useful data is to be written per linking area one byte of the three has to constitute a single data unit unavoidably. Therefore, as shown in Fig. 15c, only one 309-byte row is filled in a 30x309 data block and other 29 rows are all filled with dummy data. This means that 29-byte dummy data is 15 added to 1-byte useful data at every column. Afterwards, RS(62,30,33) encoding system is applied to each column of the dummy-added 30 bytes to append 32-byte parity thereto.

In order to restore useful data written in a linking area as before, a decoding process, namely, reverse sequence of the 20 above-explained writing process, is conducted.

In case that two same frames constitute a single linking area as illustrated in Fig. 4b, the user data space of a linking frame may be filled with 114-byte useful data and 32-byte parity as shown in Fig. 4a. In the recording example of 25 Fig. 4a, a different method from the described in Fig. 4b or 4c is used in channel encoding to ensure data reliability. The different method is explained with reference to Fig. 16.

Useful data is collected up to 2048 bytes first (S1). 4-byte EDC (Error Detection Code) is appended to a useful data 30 block composed of the collected 2048 bytes (S2). The 2052 bytes including EDC is divided into eighteen 114-byte data units (S3). The first data unit is scrambled (S4) and 9-byte physical

address is added theretofore (S5). The 93-byte dummy data is added to the 123-byte data unit including the physical address and is encoded by RS(248,216,33) system, whereby 32-byte parity is appended to the data unit. The added 93 bytes are removed to 5 produce 155-byte frame data (S6) which is then 17PP-modulated. Finally, the aforementioned 30-channel-bit frame sync is added in front of the frame data to make a complete linking frame of 1932 channel bits (S7).

The above-explained sequential processes (S4-S7) are 10 applied to the next divided 114-byte data unit to make another linking frame. Thusly-made two linking frames are written in a linking area, as a result, the structure illustrated in Fig. 4a is formed.

When each 114-byte data unit is scrambled in the above 15 processes, a physical address is used in scrambling as explained before. Same or different physical address, which is written in an RUB located before or behind a linking area, is used for the first and the second linking frame of a linking area. In case of using different address, the first linking 20 frame uses an address written before a linking frame while the second uses another address behind the linking frame.

The physical address to be written in each linking frame may be composed of 4-byte actual address, 1-byte reserved, and 4-byte parity as mentioned before. In this case, the 4-byte 25 parity is produced by applying RS(9,5,5) channel coding system to the 5 bytes.

In addition, the 4-byte actual address is composed of 27-bit address and 5-bit address identifier that is used to distinguish individual physical addresses in linking areas.

30 A pair of '00000/11110' or '00001/11111' may be used as address identifier. In case of using the former (or the latter), '00000' (or '00001') is inserted in a physical address in one

linking frame while '11110' (or '11111') is inserted in the other linking frame.

In the above explanation, it was described that the new frame sync 'FS n', which is different from the syncs 'FS0-FS6' for data frames written in physical clusters, can be used for linking frames. In case of using the new frame sync different from syncs of data frames, data to be written in physical clusters is encrypted with frame sync in a linking frame in order that digital contents recorded on a BD-ROM can be protected against illegal copy.

Although contents with such encrypted data recorded on a BD-ROM are copied onto a rewritable disc, e.g., a BD-RE, the new frame sync 'FS n' in a linking frame is not copied onto a BD-RE and it is not created either during a BD-RE recording as well. That is, a key having been used in encryption is not obtainable during reproduction of copied contents on a BD-RE, so that it is impossible to decrypt. Consequently, contents on a BD-ROM can be protected against illegal copy.

The above-explained structure of a linking area of a high-density read-only recording medium according to the present invention ensures reproduction compatibility with a rewritable recording medium such as a BD-RE when being reproduced by a disc player or a disc drive. In addition, the present structure of a linking area makes it possible for a disc player or a disc drive to conduct adequate operations by telling a read-only recording medium from a rewritable one very fast, if needed. Moreover, useful information can be reliably stored in a linking area through the above-explained recording manners.

Although certain specific embodiments of the present invention have been disclosed, it is noted that the present invention may be embodied in other forms without departing

from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all 5 changes that come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

# CLAIMS

1. A read-only recording medium where data has been recorded, including a linking area to link neighboring two sections of the data before and after the linking area, wherein  
5 at least one sync signal indicative of a linking area has been written in the linking area.

2. The recording medium of claim 1, wherein said sync signal is different from a sync signal written in the data section.

10 3. The recording medium of claim 1, wherein said sync signal is different from a sync signal written on a rewritable recording medium during data recording.

4. The recording medium of claim 1, wherein said linking area has same size with a linking area of a rewritable  
15 recording medium to link neighboring two data sections thereon.

5. The recording medium of claim 1, wherein said linking area includes three sync signals.

6. The recording medium of claim 5, wherein said three sync signals are different each other and their recorded order  
20 is reverse of recorded order of three sync signals written in a linking area of a rewritable recording medium.

7. The recording medium of claim 1, wherein said linking area is composed of two linking frames of same size.

8. The recording medium of claim 7, wherein each linking  
25 frame includes said sync signal at its front.

9. The recording medium of claim 8, wherein either of said two sync signals written respectively in the linking frames is different from a sync signal written in the data section.

30 10. The recording medium of claim 9, wherein each sync signal is composed of a sync pattern and a sync identifying

pattern that is '100 101', '101 010', '010 101' or '101 001'.

11. The recording medium of claim 10, wherein the sync signal written in one linking frame of the two has a sync identifying pattern of '100 101' while the sync signal in the  
5 other linking frame has '101 010'.

12. The recording medium of claim 8, wherein a value of '00' is written just behind the sync signal of each linking frame.

13. The recording medium of claim 12, wherein a physical  
10 address is written just behind the value of '00'.

14. The recording medium of claim 8, wherein a value of '08h' is written just behind the sync signal of each linking frame.

15. The recording medium of claim 14, wherein an entire  
15 space behind the value of '08h' is filled with '00h' in each linking frame.

16. The recording medium of claim 15, wherein the value '00h' is written after being scrambled.

17. The recording medium of claim 16, wherein a physical  
20 address has been fully or partially used as a key value in the scrambling.

18. The recording medium of claim 17, wherein said physical address having been used in the scrambling is a physical address written in a leading or a following data  
25 section closest to the linking frame.

19. The recording medium of claim 8, wherein said each linking frame is composed of the sync signal, a physical address, user data, and a parity for error correction.

20. The recording medium of claim 19, wherein said parity  
30 is created by applying RS(248,216,33) encoding system to the physical address and the user data to which dummy data is added.

21. The recording medium of claim 19, wherein said user

data has been scrambled.

22. The recording medium of claim 21, wherein the scrambling uses fully or partially a physical address that is written in a leading or a following data section closest to 5 each linking frame.

23. The recording medium of claim 19, wherein said physical address is composed of an actual address, a reserved, and a parity.

24. The recording medium of claim 23, wherein said actual 10 address includes a 5-bit address identifier.

25. The recording medium of claim 24, wherein said address identifier of the actual address written in each linking frame is differently chosen from a pair of '00000/11110' or '00001/11111'.

15 26. A method of forming data on a read-only recording medium, comprising the steps of:

forming a linking area to link neighboring two sections of the data before and after the linking area while recording the data onto the read-only recording medium; and

20 writing in the linking area at least one sync signal indicative of the linking area.

27. The method of claim 26, wherein said sync signal is different from a sync signal written in the data section.

28. The method of claim 26, wherein said sync signal is 25 different from a sync signal written on a rewritable recording medium during data recording.

29. The method of claim 26, wherein said linking area has same size with a linking area of a rewritable recording medium to link neighboring two data sections thereon.

30 30. The method of claim 26, wherein said linking area is formed to be composed of two linking frames of same size.

31. The method of claim 30, wherein each linking frame is

formed to include said sync signal at its front.

32. The method of claim 31, wherein either of said two sync signals written respectively in the linking frames is different from a sync signal written in the data section.

5 33. The method of claim 32, wherein each sync signal is composed of a sync pattern and a sync identifying pattern that is '100 101', '101 010', '010 101' or '101 001'.

34. The method of claim 33, wherein the sync signal written in one linking frame of the two has a sync identifying  
10 pattern of '100 101' while the sync signal in the other linking frame has a pattern of '101 010'.

35. The method of claim 31, wherein a value of '08h' is written just behind the sync signal of each linking frame.

36. The method of claim 35, wherein an entire space  
15 behind the value of '08h' is filled with '00h' in each linking frame.

37. The method of claim 36, wherein the value '00h' is written after being scrambled.

38. The method of claim 37, wherein a physical address  
20 has been fully or partially used as a key value in the scrambling.

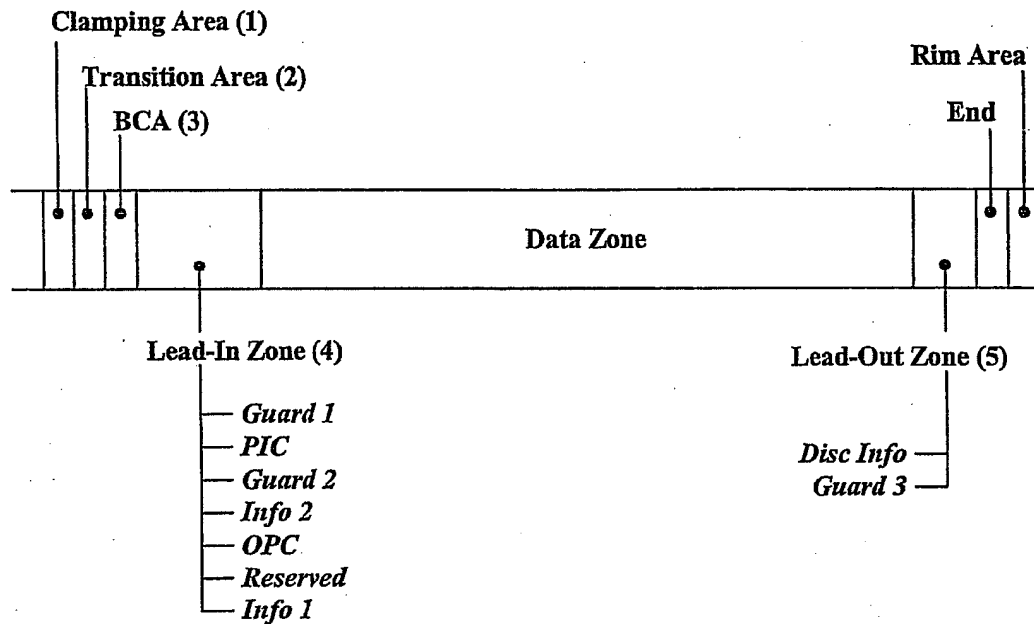
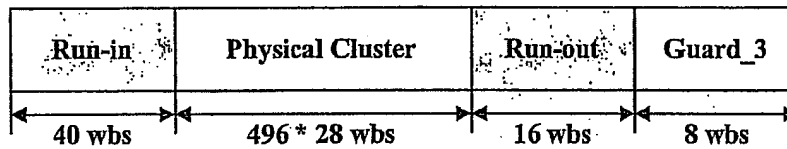
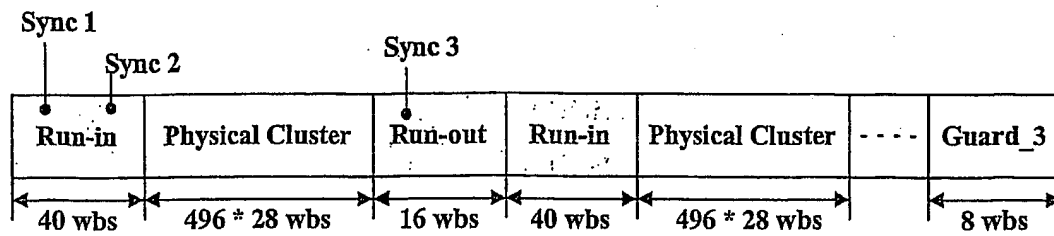
39. The method of claim 38, wherein said physical address having been used in the scrambling is a physical address having been written or to be written in a leading or a following data  
25 section closest to the linking frame.

40. A method of reproducing a read-only recording medium, wherein said recording medium with recorded data includes a linking area to link neighboring two sections of the data before and after the linking area, wherein at least one sync  
30 signal indicative of a linking area has been written in the linking area.

41. An apparatus of reproducing a read-only recording



medium, wherein said recording medium with recorded data includes a linking area to link neighboring two sections of the data before and after the linking area, wherein at least one sync signal indicative of a linking area has been written in  
5 the linking area.

**FIG. 1A****FIG. 1B***Single written Recording Unit Block (RUB)***FIG. 1C***Continuously written sequence of Recording Unit Blocks*

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**FIG. 1D**

Run-In	Physical Cluster	Run-Out	Run-In
2760 Channel Bit	958272 Channel Bit (Recoding Frames #0 - #30)	1104 Channel Bit	2760 Channel Bit

Frame Number	Frame Sync	Frame Number	Frame Sync
Frame #0	FS 0	Frame #16	FS 5
Frame #1	FS 1	Frame #17	FS 3
Frame #2	FS 2	Frame #18	FS 2
Frame #3	FS 3	Frame #19	FS 2
Frame #4	FS 3	Frame #20	FS 5
Frame #5	FS 1	Frame #21	FS 6
Frame #6	FS 4	Frame #22	FS 5
Frame #7	FS 1	Frame #23	FS 1
Frame #8	FS 5	Frame #24	FS 1
Frame #9	FS 5	Frame #25	FS 6
Frame #10	FS 4	Frame #26	FS 2
Frame #11	FS 3	Frame #27	FS 6
Frame #12	FS 4	Frame #28	FS 4
Frame #13	FS 6	Frame #29	FS 4
Frame #14	FS 6	Frame #30	FS 2
Frame #15	FS 3		

**FIG. 1E**

Sync Number	24-bit sync body	6-bit sync ID
FS 0	01 010 000 000 010 000 000 010	000 001
FS 1	01 010 000 000 010 000 000 010	010 010
FS 2	01 010 000 000 010 000 000 010	101 000
FS 3	01 010 000 000 010 000 000 010	100 001
FS 4	01 010 000 000 010 000 000 010	000 100
FS 5	01 010 000 000 010 000 000 010	001 001
FS 6	01 010 000 000 010 000 000 010	010 000

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FIG. 2A

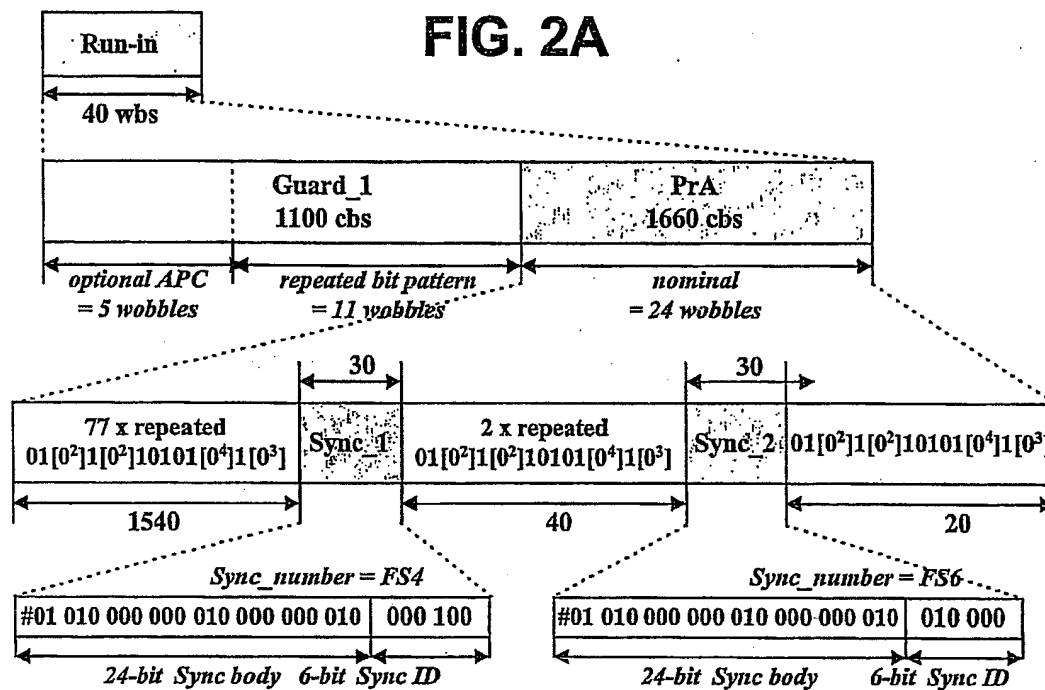
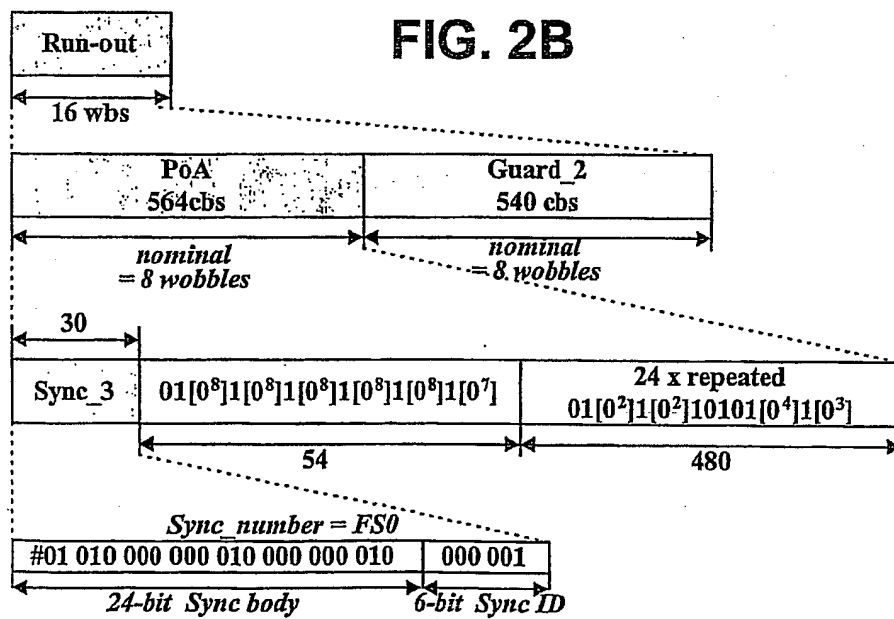


FIG. 2B



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FIG. 3A

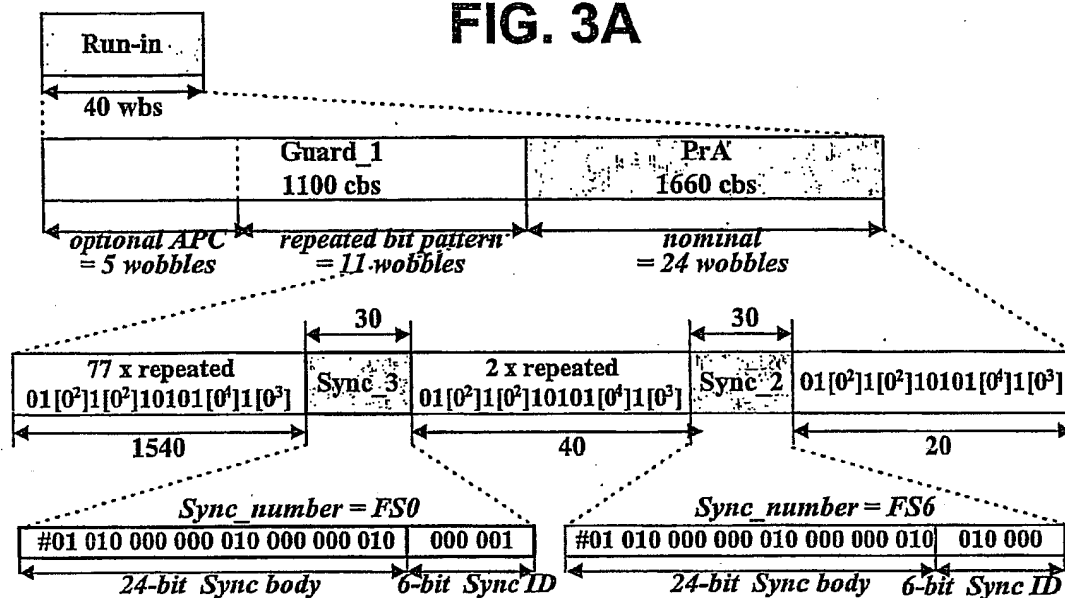
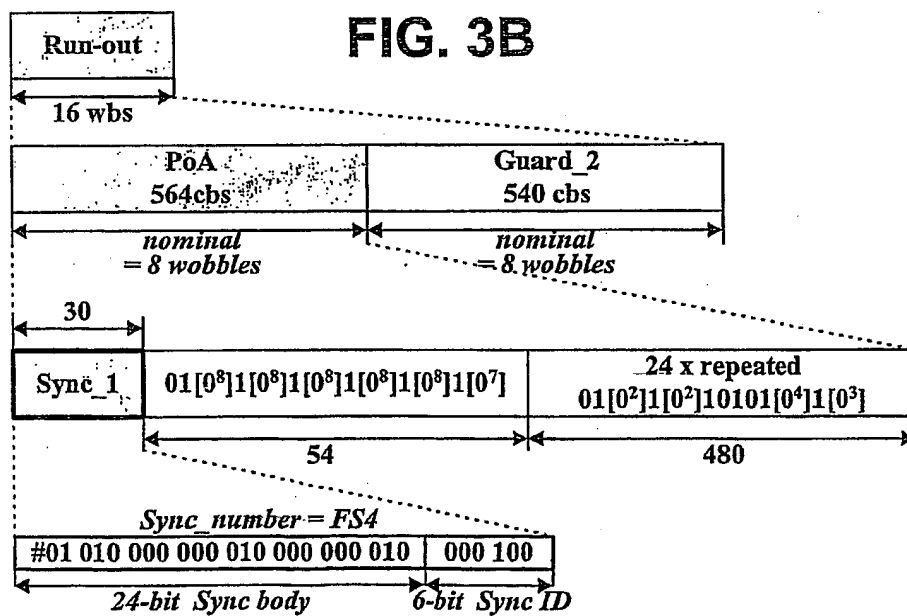
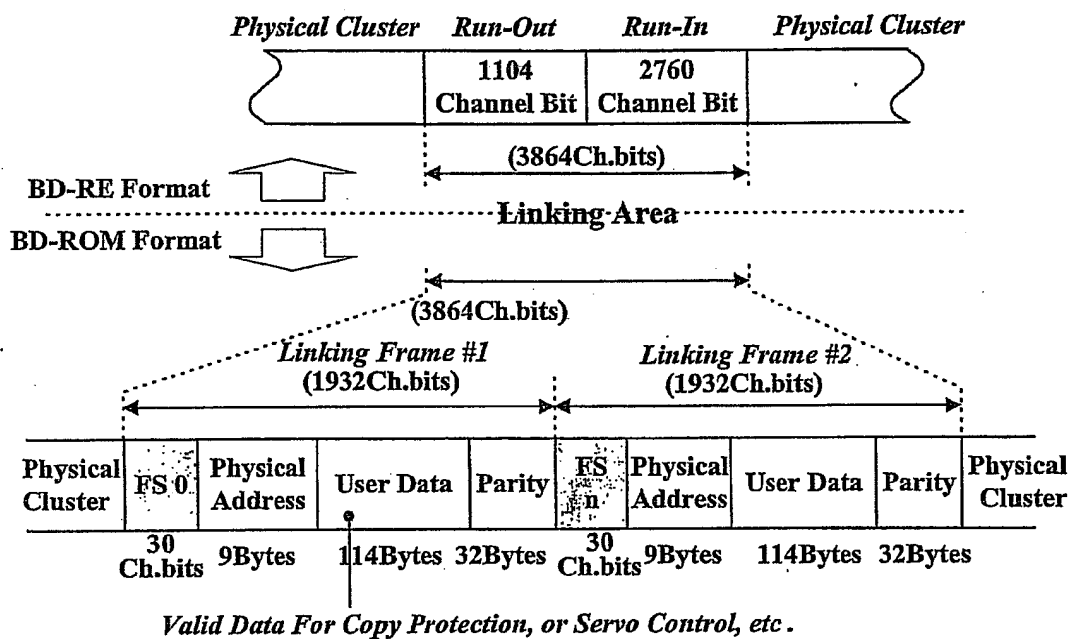
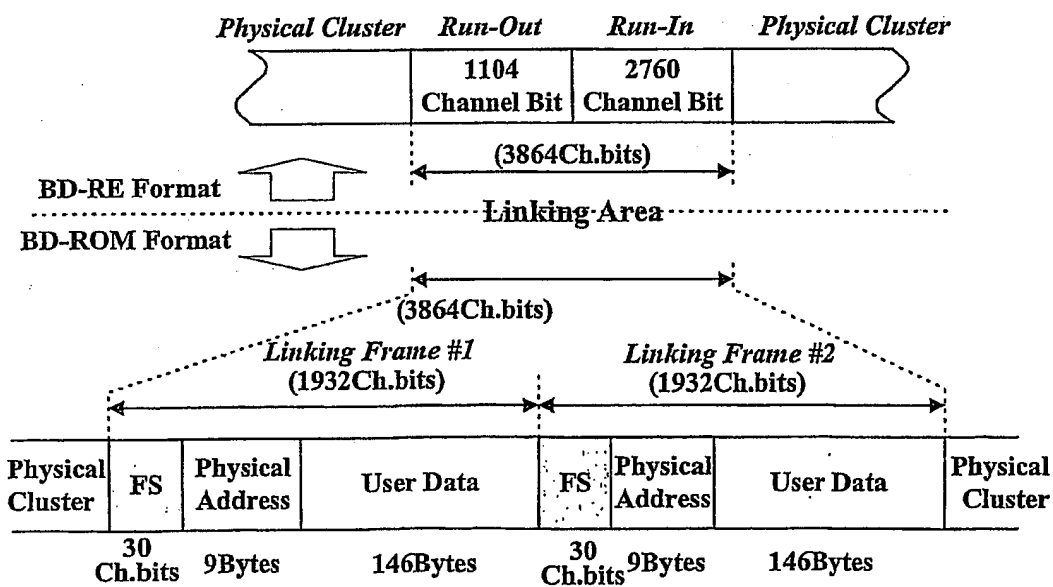


FIG. 3B



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**FIG. 4A****FIG. 4B**

**FIG. 4C**

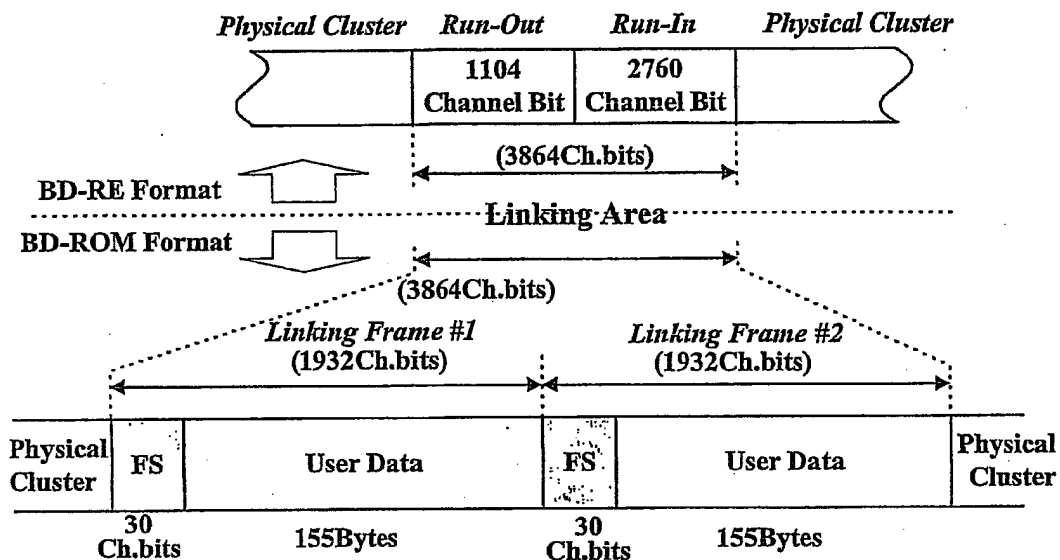
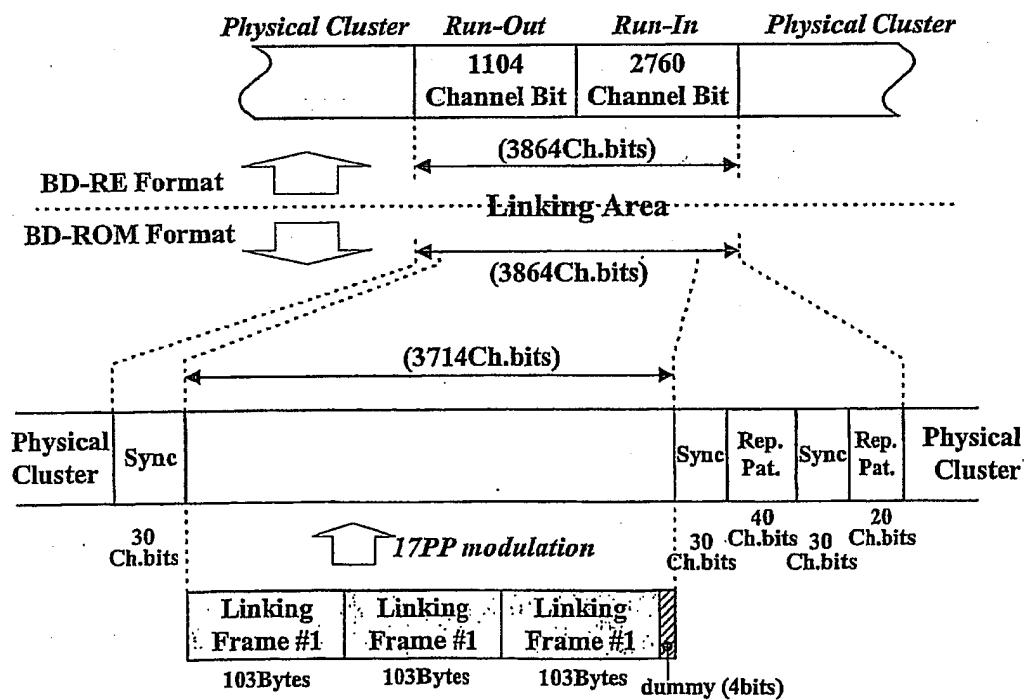


FIG. 4D



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FIG. 5

<i>FS n (new)</i>	01 010 000 000 010 000 000 010	<i>FS 7 : 100 101</i> <i>FS 8 : 101 010</i> <i>FS 9 : 010 101</i> <i>FS 10: 101 001</i>
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FIG. 6A

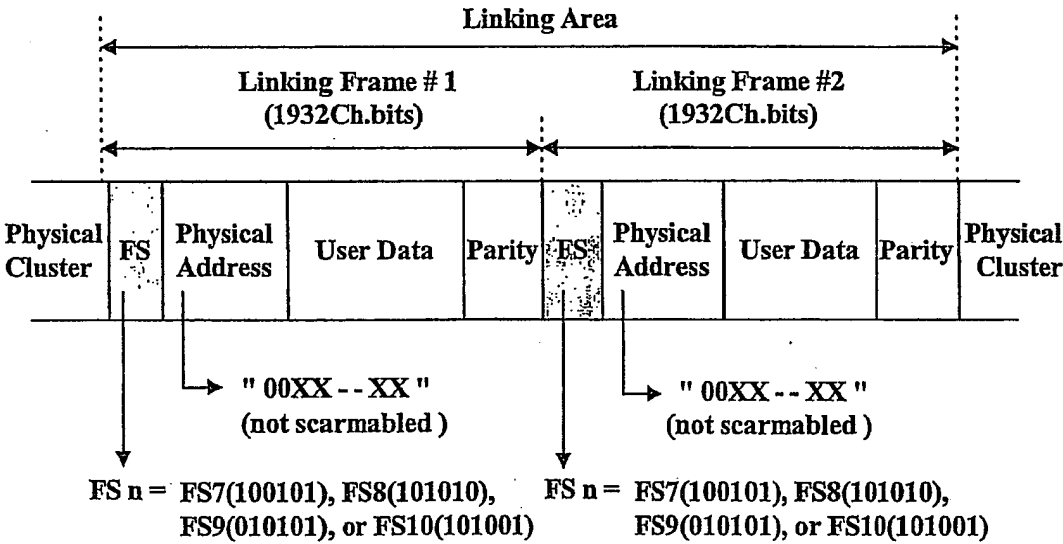


FIG. 6B

	Case 1	Case 2	Case 3	Case 4
FS #1	FS0	FS0	FS7, 8, or 9	FS10
FS #2	FS7	FS10	FS7, 8, or 9	FS10



**FIG. 7A**

Sync 1 : FS0, Sync 2 : FS7

Frame n	Frame n-1	Frame n-2	Frame n-3	Frame Number	
FS0	FS7	FS0	FS2	0	→ (1) A
FS0	FS2	FS4	FS4	0	→ (2)
FS0	FS2	FS4	FS4	31	
FS1	FS0	FS7/FS2	FS0/FS4	1	→ (3)
FS1	FS3	FS3	FS2	5	
FS1	FS4	FS1	FS3	7	
FS1	FS5	FS6	FS5	23	
FS1	FS1	FS5	FS6	24	
FS2	FS1	FS0	FS7/FS2	2	→ (4)
FS2	FS3	FS5	FS3	18	
FS2	FS2	FS3	FS5	19	
FS2	FS6	FS1	FS1	26	
FS2	FS4	FS4	FS6	30	
FS3	FS2	FS1	FS0	3	
FS3	FS3	FS2	FS1	4	
FS3	FS4	FS5	FS5	11	
FS3	FS6	FS6	FS4	15	
FS3	FS5	FS3	FS6	17	
FS4	FS1	FS3	FS3	6	
FS4	FS5	FS5	FS1	10	
FS4	FS3	FS4	FS5	12	
FS4	FS6	FS2	FS6	28	
FS4	FS5	FS3	FS6	29	
FS5	FS1	FS4	FS1	8	
FS5	FS5	FS1	FS4	9	
FS5	FS3	FS6	FS6	26	
FS5	FS2	FS2	FS3	20	
FS5	FS6	FS5	FS2	22	
FS6	FS4	FS3	FS4	13	
FS6	FS6	FS4	FS3	14	
FS6	FS5	FS2	FS2	21	
FS6	FS1	FS1	FS5	25	
FS6	FS2	FS6	FS1	27	
FS7	FS0	2	FS4	32	

(1) : Frame Number 0 for the 1<sup>st</sup> AUN(Address Unit) of RUB

(2) : Frame Number 0 for the the Middle AUN(Address Unit) of RUB

(3) : Frame Number 1 (1<sup>st</sup> AUN(Address Unit) of RUB / Middle AUN(Address Unit) of RUB)(4) : Frame Number 2 (1<sup>st</sup> AUN(Address Unit) of RUB / Middle AUN(Address Unit) of RUB)

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**FIG. 7B**

Sync 1 : FS7, Sync 2 : FS7

Frame n	Frame n-1	Frame n-2	Frame n-3	Frame Number	
FS0	FS7/FS2	FS7/FS4	FS2/FS4	0	➤ (1)
FS1	FS0	FS7/FS2	FS7/FS4	1	➤ (2)
FS1	FS3	FS3	FS2	5	
FS1	FS4	FS1	FS3	7	
FS1	FS5	FS6	FS5	23	
FS1	FS1	FS5	FS6	24	
FS2	FS1	FS0	FS7/FS2	2	➤ (3)
FS2	FS3	FS5	FS3	18	
FS2	FS2	FS3	FS5	19	
FS2	FS6	FS1	FS1	26	
FS2	FS4	FS4	FS6	30	
FS3	FS2	FS1	FS0	3	
FS3	FS3	FS2	FS1	4	
FS3	FS4	FS5	FS5	11	
FS3	FS6	FS6	FS4	15	
FS3	FS5	FS3	FS6	17	
FS4	FS1	FS3	FS3	6	
FS4	FS5	FS5	FS1	10	
FS4	FS3	FS4	FS5	12	
FS4	FS6	FS2	FS6	28	
FS4	FS5	FS3	FS6	29	
FS5	FS1	FS4	FS1	8	
FS5	FS5	FS1	FS4	9	
FS5	FS3	FS6	FS6	26	
FS5	FS2	FS2	FS3	20	
FS5	FS6	FS5	FS2	22	
FS6	FS4	FS3	FS4	13	
FS6	FS6	FS4	FS3	14	
FS6	FS5	FS2	FS2	21	
FS6	FS1	FS1	FS5	25	
FS6	FS2	FS6	FS1	27	
FS7	FS2	FS4	FS4	31	
FS7	FS7	FS2	FS4	32	

- (1) : Frame Number 0 (1<sup>st</sup> AUN(Address Unit) of RUB / Middle AUN(Address Unit) of RUB)  
 (2) : Frame Number 1 (1<sup>st</sup> AUN(Address Unit) of RUB / Middle AUN(Address Unit) of RUB)  
 (3) : Frame Number 2 (1<sup>st</sup> AUN(Address Unit) of RUB / Middle AUN(Address Unit) of RUB)

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**FIG. 7C**

Sync 1 : FS7, Sync 2 : FS8

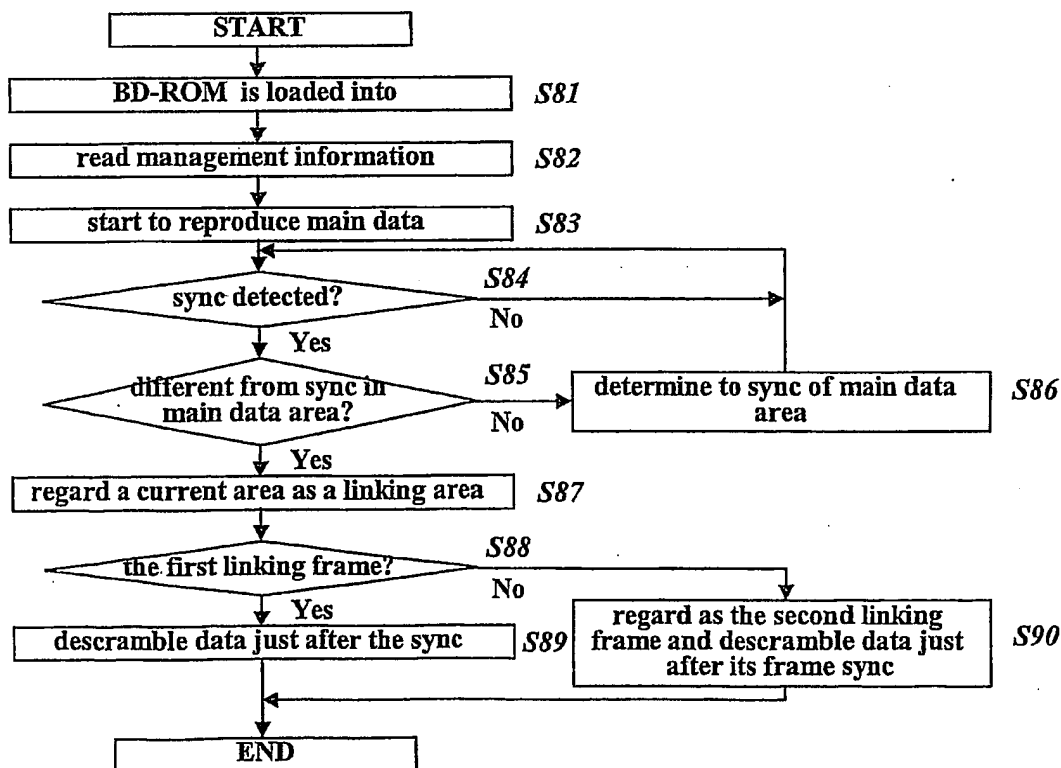
Frame n	Frame n-1	Frame n-2	Frame n-3	Frame Number	
FS0	FS8/FS2	FS7/FS4	FS2/FS4	0	→ (1)
FS1	FS0	FS8/FS2	FS7/FS4	1	→ (2)
FS1	FS3	FS3	FS2	5	
FS1	FS4	FS1	FS3	7	
FS1	FS5	FS6	FS5	23	
FS1	FS1	FS5	FS6	24	
FS2	FS1	FS0	FS7/FS2	2	→ (3)
FS2	FS3	FS5	FS3	18	
FS2	FS2	FS3	FS5	19	
FS2	FS6	FS1	FS1	26	
FS2	FS4	FS4	FS6	30	
FS3	FS2	FS1	FS0	3	
FS3	FS3	FS2	FS1	4	
FS3	FS4	FS5	FS5	11	
FS3	FS6	FS6	FS4	15	
FS3	FS5	FS3	FS6	17	
FS4	FS1	FS3	FS3	6	
FS4	FS5	FS5	FS1	10	
FS4	FS3	FS4	FS5	12	
FS4	FS6	FS2	FS6	28	
FS4	FS5	FS3	FS6	29	
FS5	FS1	FS4	FS1	8	
FS5	FS5	FS1	FS4	9	
FS5	FS3	FS6	FS6	26	
FS5	FS2	FS2	FS3	20	
FS5	FS6	FS5	FS2	22	
FS6	FS4	FS3	FS4	13	
FS6	FS6	FS4	FS3	14	
FS6	FS5	FS2	FS2	21	
FS6	FS1	FS1	FS5	25	
FS6	FS2	FS6	FS1	27	
FS7	FS2	FS4	FS4	31	
FS8	FS7	FS2	FS4	32	

- (1) : Frame Number 0 (1<sup>st</sup> AUN(Address Unit) of RUB / Middle AUN(Address Unit) of RUB)  
 (2) : Frame Number 1 (1<sup>st</sup> AUN(Address Unit) of RUB / Middle AUN(Address Unit) of RUB)  
 (3) : Frame Number 2 (1<sup>st</sup> AUN(Address Unit) of RUB / Middle AUN(Address Unit) of RUB)

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**FIG. 7D***17PP modulation code conversion table*

data bits	modulation bits	
00 00 00 00	010 100 100 100	
00 00 10 00	000 100 100 100	
00 00 00	010 100 000	
00 00 01	010 100 100	
00 00 10	000 100 100	
00 00 11	000 100	
00 01	010 100	
00 10	010 000	
00 11	010 100	
01	010	
10	001	
11	000	if preceding modulation bits = xx1
	101	if preceding modulation bits = xx0

**FIG. 8**

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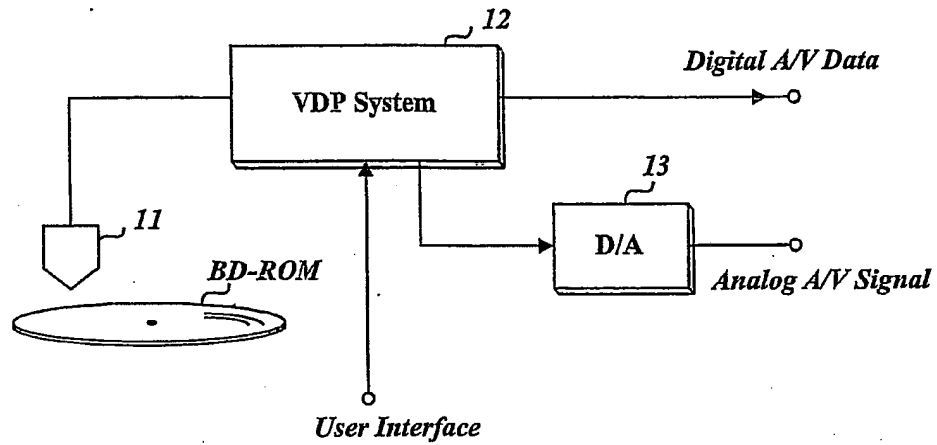
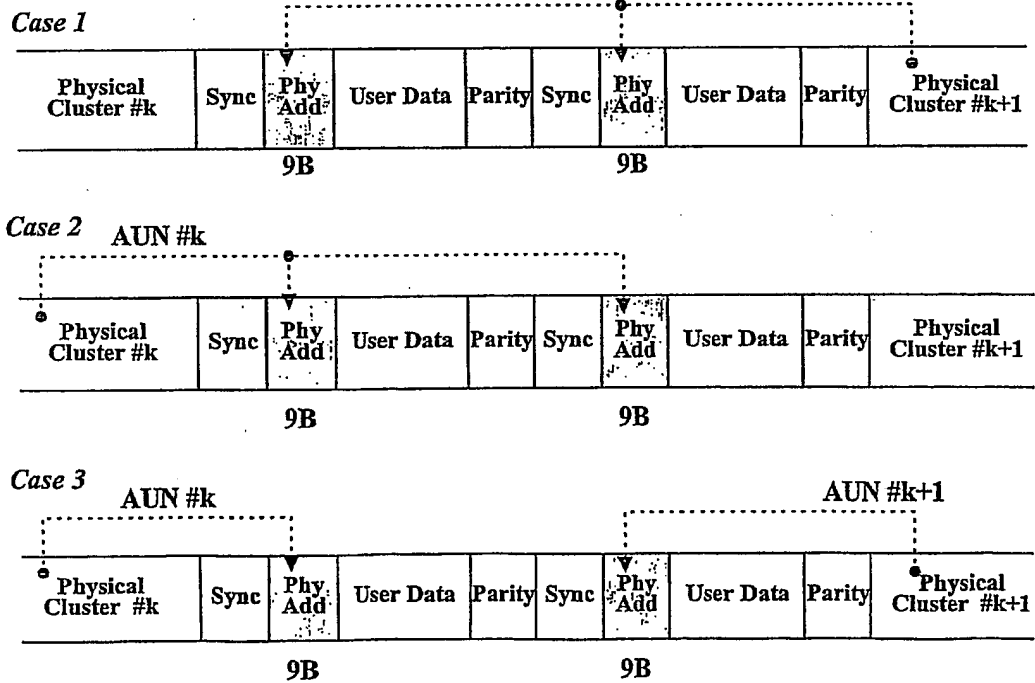
**FIG. 9****FIG. 10A**

FIG. 10B

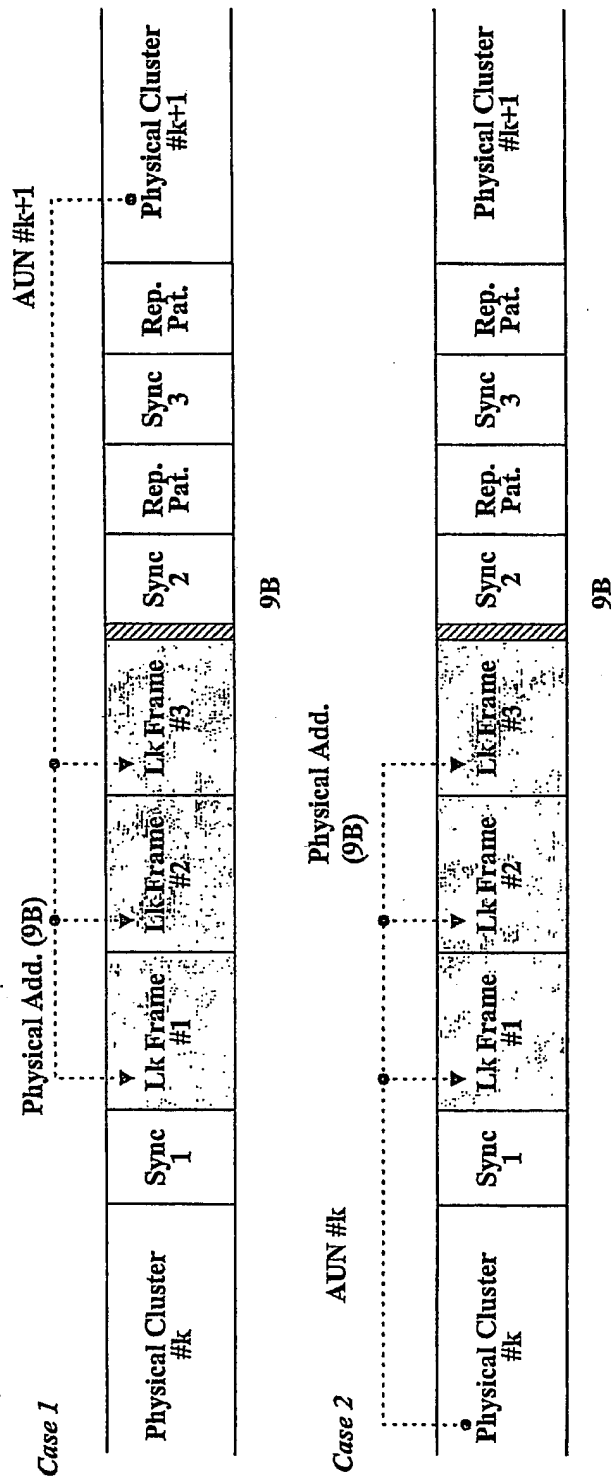
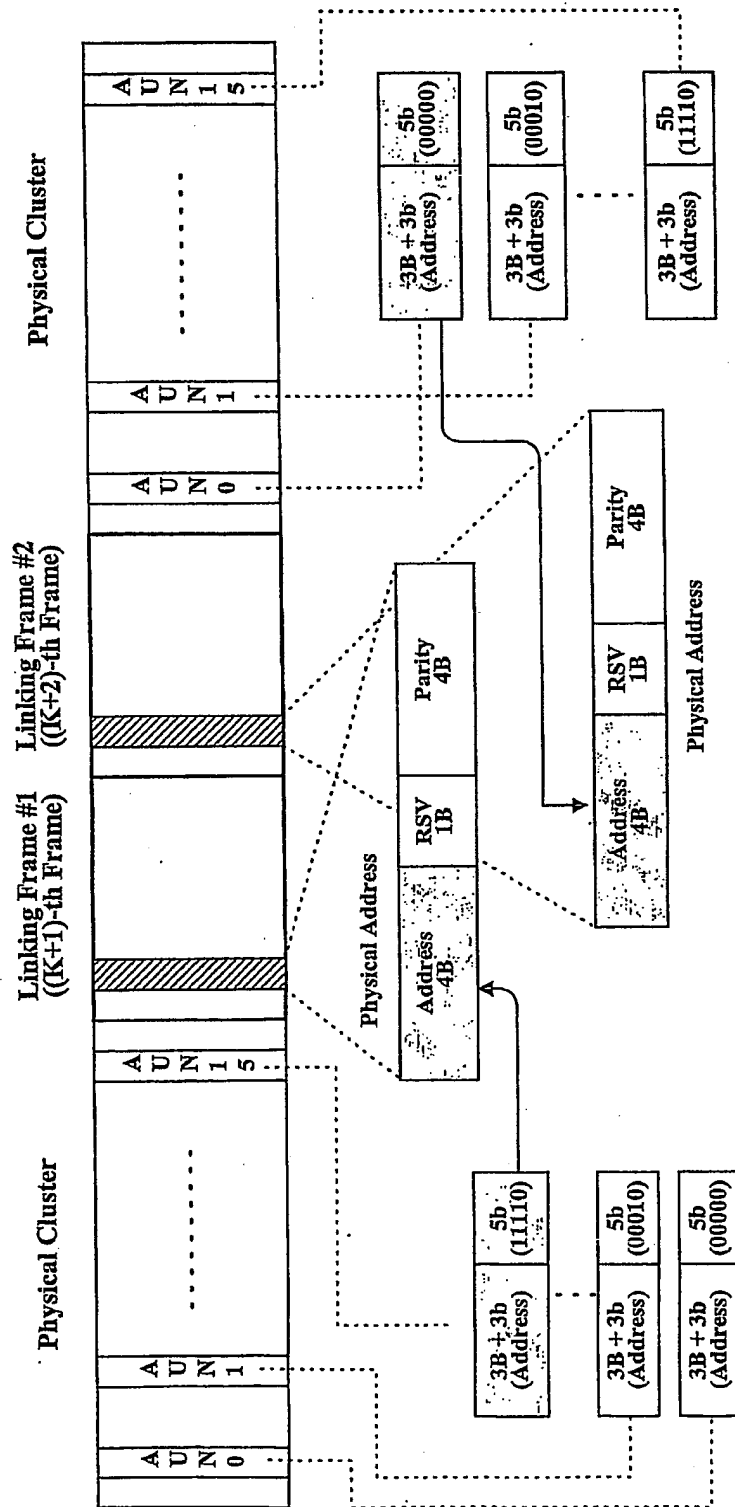
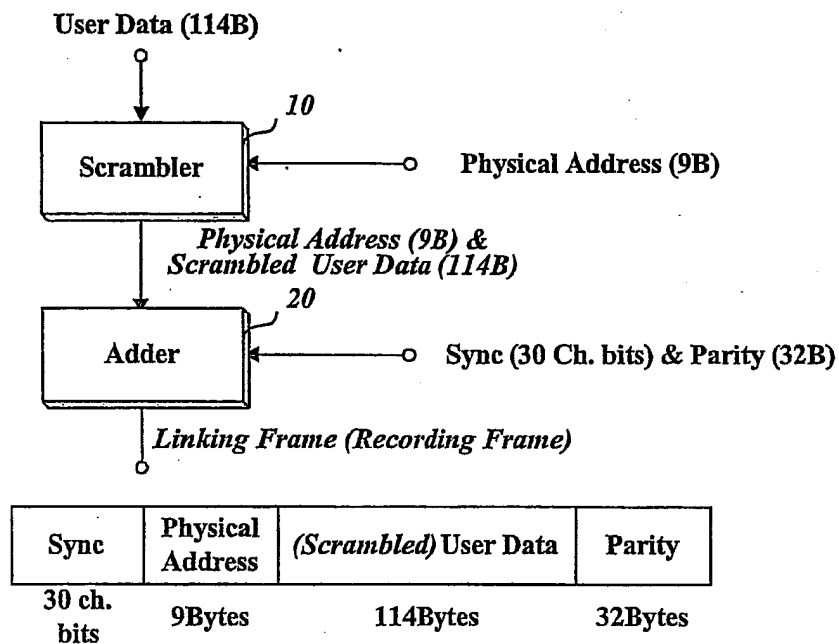
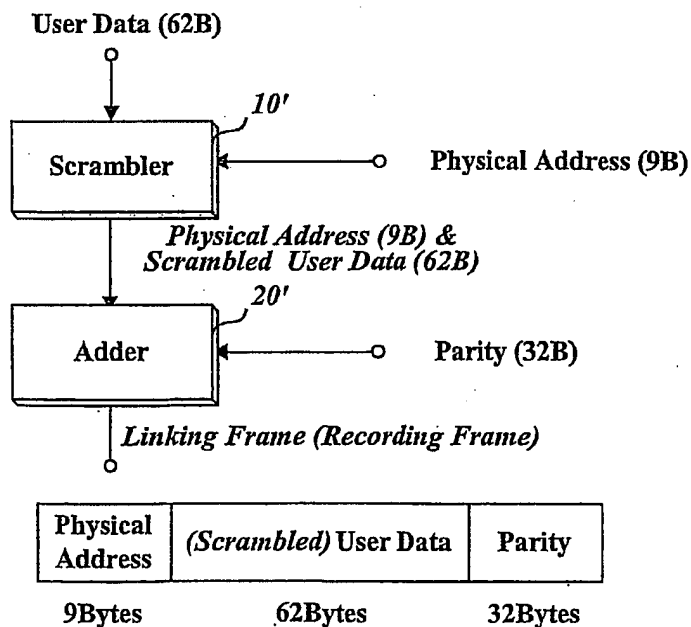


FIG. 10C



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**FIG. 11A****FIG. 11B**



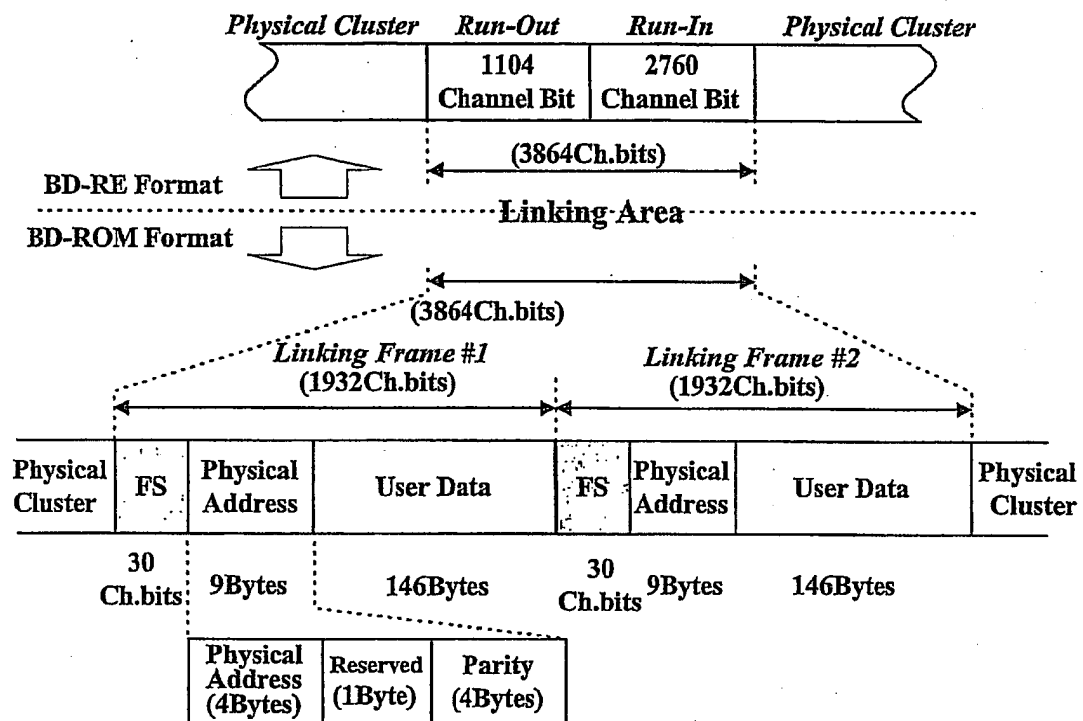
**FIG. 12A**

FIG. 12B

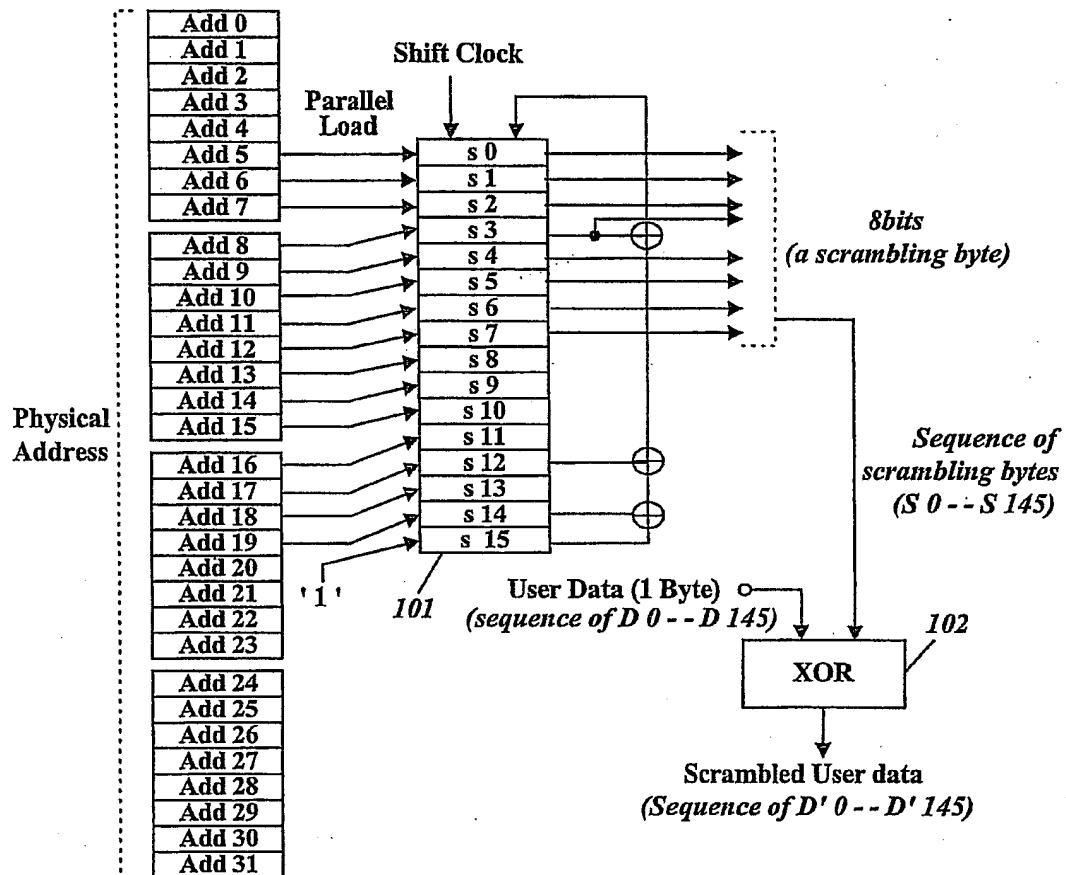
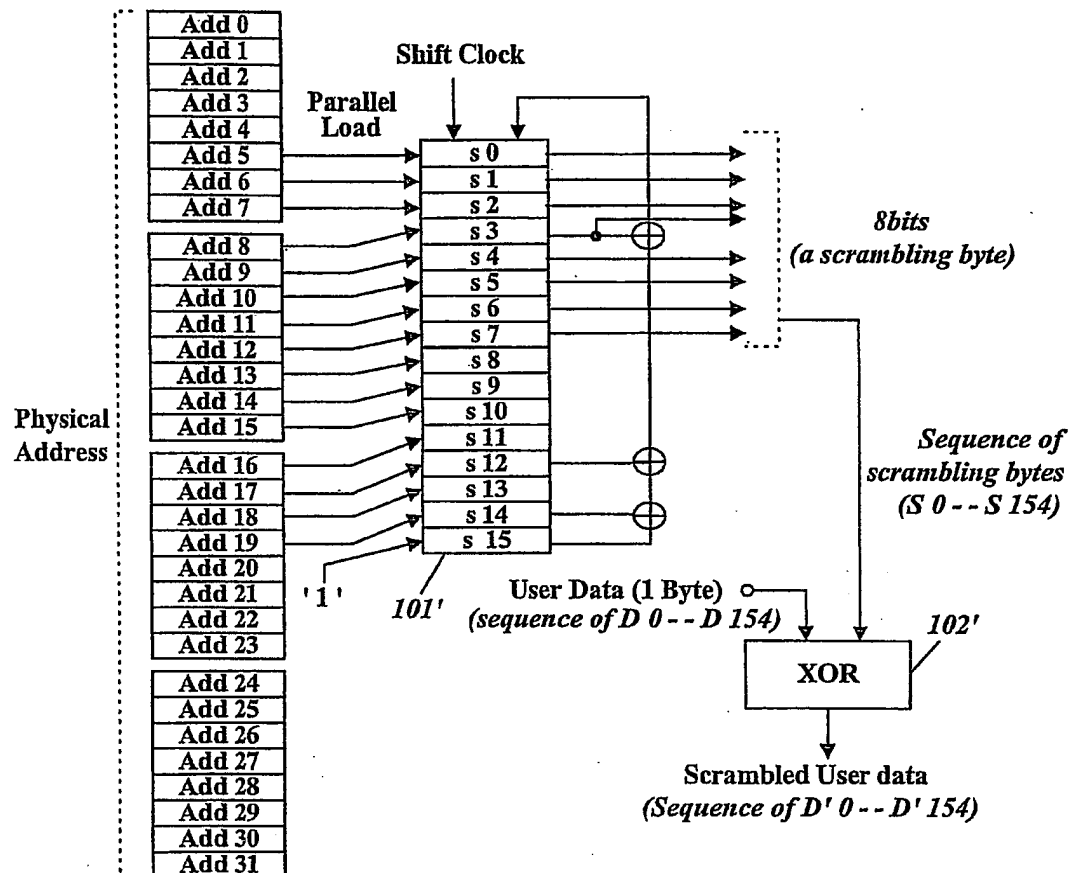


FIG. 13



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FIG. 14A

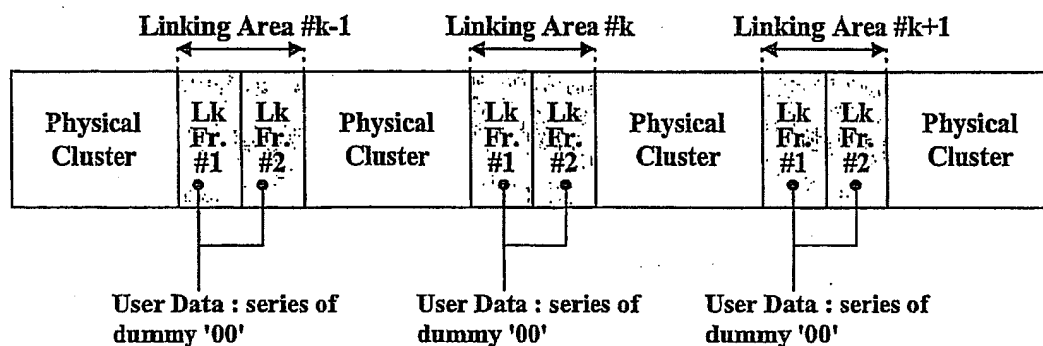


FIG. 14B

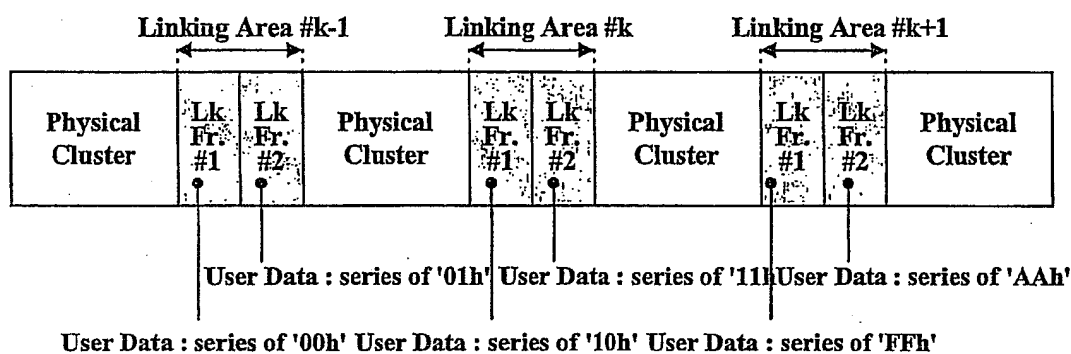
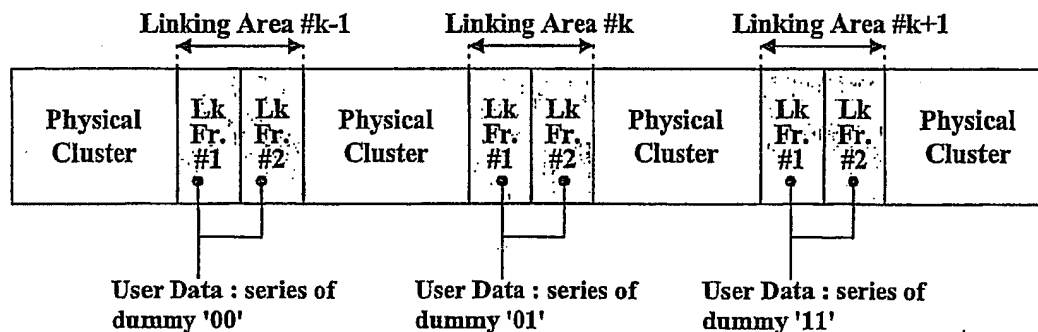
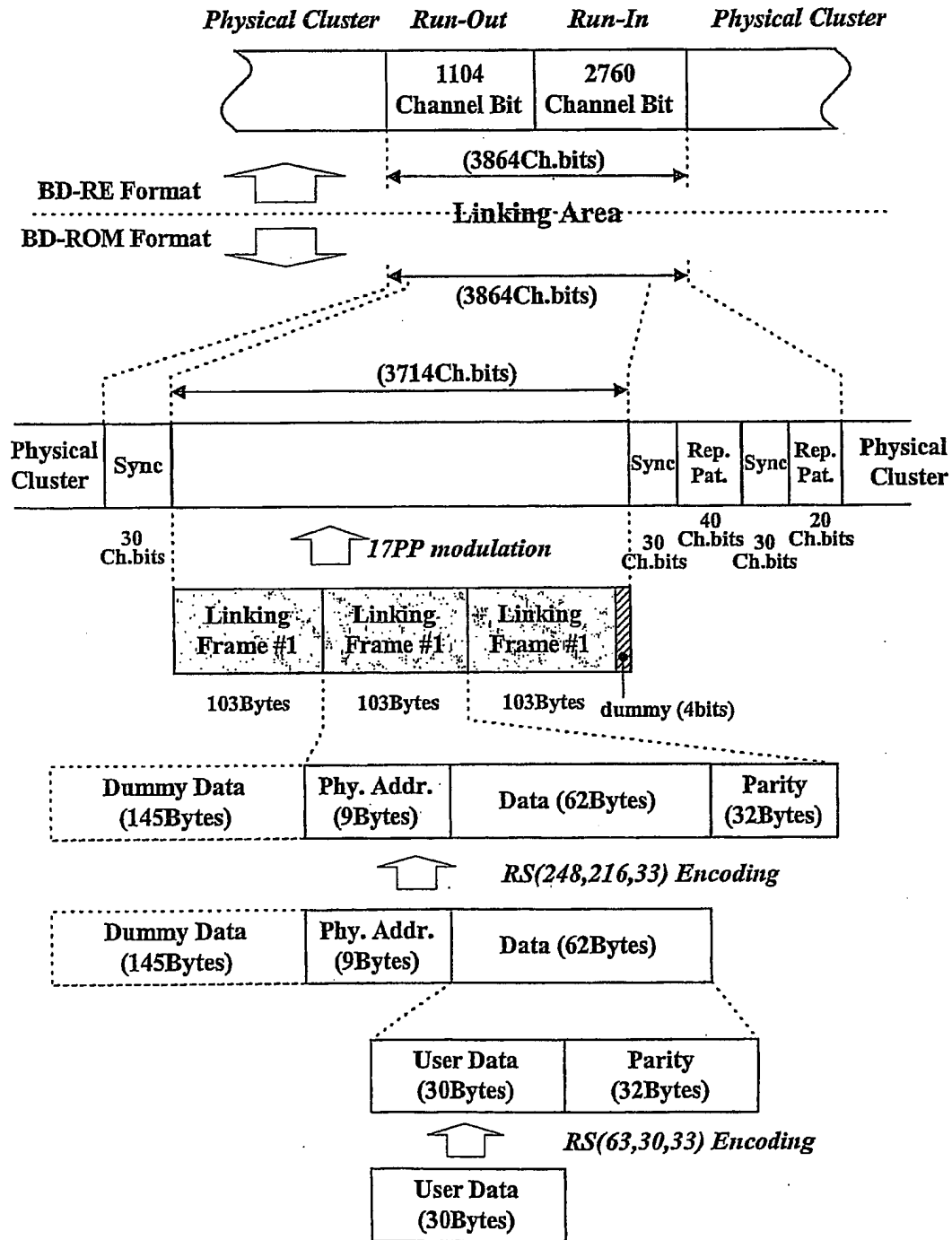


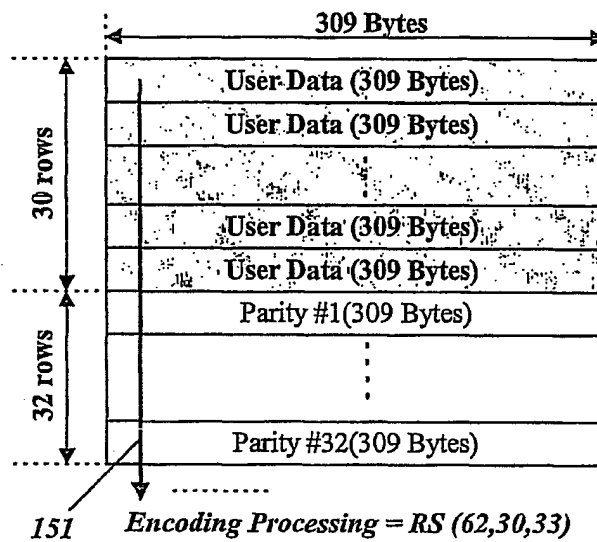
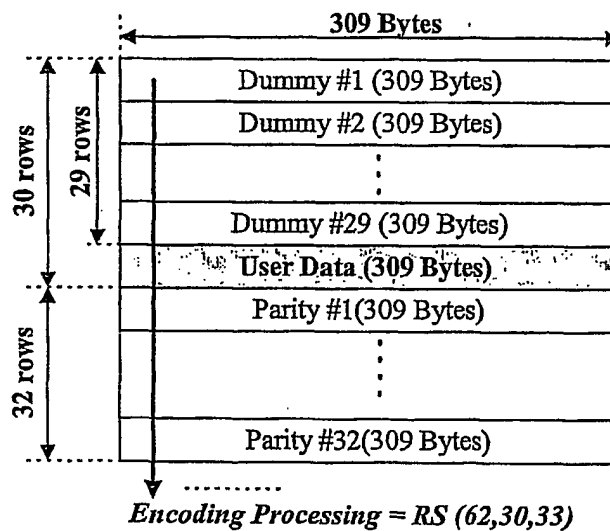
FIG. 14C



**FIG. 15A**

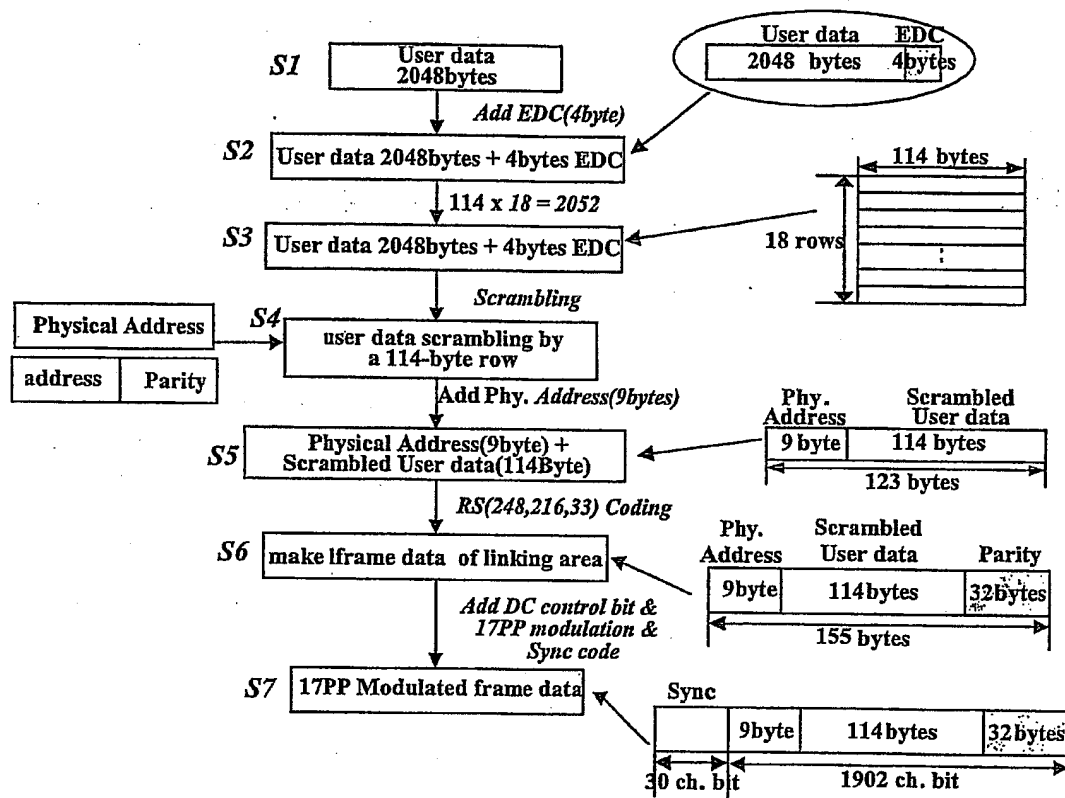


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**FIG. 15B****FIG. 15C**

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FIG. 16



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR03/01096

**A. CLASSIFICATION OF SUBJECT MATTER****IPC7 G11B 20/12**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G11B 20/12 G11B 20/10 G06F 7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions since 1975

Korean Utility models and applications for utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1022735 A2(VICTOR) 26 JULY 2000 See the whole documents & JP 2000-215452, & US 6477127 B1	1,26,40,41
A	JP 2000-137952 A(VICTOR) 16 MAY 2000 See the abstract	1,26,40,41
A	JP 11-296996 A(RICOH) 29 OCTOBER 1999 See the abstract and Fig.2, Fig.3	1,26,40,41
P, A	JP 2002-260339 A(PIONEER) 13 SEPTEMBER 2002 See the whole document	1,26,40,41

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

28 AUGUST 2003 (28.08.2003)

Date of mailing of the international search report

28 AUGUST 2003 (28.08.2003)

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